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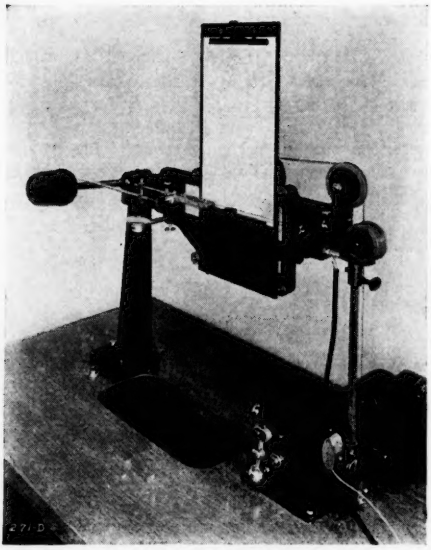

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TEXTILE RESEARCH

Publication of

United States Institute for Textile Research, Inc.
and for the Released Research Reports of
The Textile Foundation, Inc.

The Textile Drying Research Completed

LABORATORY work on the Institute's Textile Drying Research has been completed and two final progress reports will be submitted to subscribers as soon as their checking and preparation is completed; a total of 10 of these reports will then have been received. It is the opinion of the Board of Directors, and of many of the subscribers, that this research is the most important one that has been conducted by the Institute, and that its results when published will disclose much valuable new data that will have wider application than in the textile industry. A conservative report of Chairman Walker of the Administrative Committee for the research is as follows:

> "When all of the reports of the research are in the hands of textile engineers and technicians they will have for the first time quantitative data of considerable value in determining the limiting conditions of moisture regain and rates of removal of moisture in the drying of textiles, and also the effects of heat and humidity on some of the important properties of purified and commercially processed textiles. These limiting conditions and the effects of various processing treatments should be of practical service in the commercial drying of textiles without damage."

This research was organized and initially financed in 1937 on the Institute's co-operative basis, and has been conducted at the National Bureau of Standards under their research associate plan. It is particularly notable because every penny of the fund subscribed and expended was furnished by the industry, whereas previous Institute studies had been financed in part by the Textile Foundation. It is significant also because the Foundation's research program has been planned on a basis that will exhaust its fund within 10 years, and will then oblige the industry to finance research if research is wanted.

The program for the drying research was drawn up after exhaustive study by the original Administrative Committee, the members of which were G. E. Hopkins, then research director, Bigelow-Sanford Carpet Co., Chairman; Dr. A. C. Walker, Bell Telephone Laboratories, and Dr. F. Bonnet, American Viscose Corp. At the end of the first year Mr. Hopkins resigned, and the Committee's work was continued by the other two members, Dr. Walker kindly assuming the responsibilities of the chairmanship. J. G. Wiegerink has been research associate for the study throughout the three years, and has not only been highly commended by the committee and by many of the co-operators, but has had his ability recognized by the Ameri-

can Viscose Corp. by the engagement of his services. The Institute's Board at their meeting May 14 formally adopted a vote expressing their very great appreciation of the work of the Administrative Committee and Mr. Wiegerink.

The Research Subscribers

Credit is also due to the textile and allied companies which by their financial and personal support made this research possible, particularly those which contributed for the entire three years. These 57 firms, with the number of years indicated that they were subscribers, are as follows:

** American Bemberg Corp., Elizabethton, Tenn.; *** American Enka Corp., Enka, N. C.; *** American Viscose Corp., Marcus Hook, Pa.; ** American Woolen Co., New York, N. Y.; ** Andrews & Goodrich, Inc., Boston, Mass.; * Apponaug Co., Apponaug, R. I.; *** Arlington Mills, Boston, Mass.

** Bell Telephone Laboratories, New York, N. Y.; * Bigelow-Sanford Carpet Co., Thompsonville, Conn.; ** Sidney Blumenthal & Co., New York, N. Y.; * Bristol Co., Waterbury, Conn.; * Brown Instrument Co., Philadelphia, Pa.; ** Burlington Mills Corp., Greensboro, N. C.; *** H. W. Butterworth & Sons Co., Philadelphia, Pa.

*** Celanese Corp. of America, New York, N. Y.; *** Collins & Aikman Corp., Philadelphia, Pa.; *** Continental Mills, Inc., Philadelphia, Pa.

*** Delaware Rayon Corp., Newcastle, Del.; *** E. I. du Pont de Nemours & Co., Rayon Div., Wilmington, Del.

*** Eavenson & Levering Co., Camden, N. J.; ** Ewing-Thomas Corp., Chester, Pa.

*** Firth Carpet Co., Auburn, N. Y.; *** Forstmann Woolen Co., Passaic, N. J.; * Foxboro Co., Foxboro, Mass.; * Frankford Worsted Mills, Philadelphia, Pa.

*** Globe Dye Works, Philadelphia, Pa.; * Goodall Worsted Co., Sanford, Maine; * Guardite Corp., Chicago, Ill.

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* National Drying Machinery Co., Philadelphia, Pa.; *** North American Rayon Corp., Elizabethton, Tenn.

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** J. O. Ross Engineering Corp., New York, N. Y.

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(Continued on page 371)

The Moisture Relations of Textile Fibres at Elevated Temperatures

By JAMES G. WIEGERINK *

A Research of U. S. Institute for Textile Research, Inc.

Abstract

The moisture contents of ten kinds of textile fibres in the form of specially prepared yarns were determined when the fibres were in equilibrium with air for a series of relative humidities and temperatures. Data were obtained for both "desorption" and "adsorption," the yarns being brought to equilibrium from a wet condition and a dry condition, respectively. The fibres studied were raw cotton, "purified" cotton, mercerized cotton, clothing wool, carpet wool, viscose rayon, cuprammonium rayon, raw silk, degummed silk and cellulose acetate. The temperatures ranged from 96° F. to 302° F. and the relative humidities ranged from 5% to 90% for temperatures below 212° F. and up to the maximum obtainable at atmospheric pressure above 212° F.

The results are given in the form of graphs showing moisture content against relative humidity and also in the form of graphs in which the logarithms of the moisture contents at given relative humidities are plotted against the reciprocals of the corresponding absolute temperatures. The last show straight line relationships with changes in the slopes of the lines between 200° F. and 220° F.

Introduction

As part of a program of investigation of the drying of textiles the moisture contents of ten kinds of textile fibres were determined when the fibres were in equilibrium with air at different relative humidities and temperatures ranging from 96° F. to 302° F. Equilibrium was approached from both the wet state (desorption) and from the dry state (adsorption). The desorption data, of importance in the drying of textiles, include measurements at nine temperatures and at as many relative humidity values at each temperature as were considered necessary or expedient. Since an analysis of the desorption data revealed a linear relationship between the logarithm of the moisture content and the reciprocal of the absolute temperature from which intermediate values could be obtained, the adsorption data, of importance in the reconditioning of textiles, were obtained for only five temperatures. Below the boiling point of water at atmospheric

* Research Associate for the United States Institute for Textile Research at the National Bureau of Standards, Washington, D. C. The establishment of this Research Associateship was made possible by funds contributed by 57 individual manufacturers.

pressure, six to ten relative humidity values at each temperature were considered sufficient to characterize the range between dryness and saturation. Above this point the maximum relative humidity attainable without recourse to a pressure system progressively decreases with increasing temperature, until at 302° F. the highest attainable relative humidity at atmospheric pressure is approximately 20%.

Materials

The textile fibres studied and the purification treatments they received are given. All were in the form of yarns. Where treatment with water is indicated, distilled water was used.

The raw cotton yarn (1/24) * was washed thoroughly in water. The "purified" cotton yarn was prepared from the raw cotton yarn by successive extractions with alcohol, ether, and 1% NaOH solution, followed by rinsing in 5% acetic acid solution and in water. The mercerized cotton yarn (2/25) was washed in a 5% NH_4OH solution, then rinsed in water. The clothing wool yarn (2/2.3) and the carpet wool yarn (3/1.2) were extracted with alcohol and ether, and raised in warm water. The viscose rayon yarn (1/30; commercial designation 150 denier, 40 filament), the cuprammonium rayon yarn (1/30; commercial designation 150 denier, 112 filament), and the cellulose acetate (1/30; commercial designation 150 denier, 46 filament) were washed in a warm 1% NH_4OH solution, then rinsed in warm water. The raw silk yarn (1/300; commercial designation 13–15 denier) was washed in water at room temperature. The degummed silk was prepared from the raw silk yarn by degumming with an olive oil soap solution, followed by rinsing in warm water.

Procedure

The equipment used for this investigation is described in detail in a previous paper (*Text. Rsch.*, June, 1940, P. 334–40). It consists of equipment for controlling the temperature and relative humidity of air, for passing a stream of this air through a working chamber at a known rate, for exposing the samples in this chamber to the air stream and weighing them in it conveniently and rapidly; and for sampling the air in the working chamber and accurately determining its relative humidity by a gravimetric measurement of the moisture content. The temperature in the working chamber was maintained constant within $\pm$ 0.4° F. and the relative humidity within $\pm$ 1% relative humidity throughout each test run. Some of the runs were 24 hours or more in duration.

The samples for the desorption experiments were conditioned by soaking overnight in distilled water. Then the excess water was removed by gently squeezing until the weights of squeezed yarns were about twice that of dry weights and the samples were then placed in the working chamber at the temperature and the initial high humidity of the test condition. They were brought to equilibrium at a series of progressively decreasing relative humidity values, weighings being made at suitable intervals until no change in weight was found over a period of approximately twelve

* The typp system for designating sizes of yarns is employed. The first number (1 in the case of the raw cotton yarn) indicates the number of units of which the yarn is composed: that is, the ply. The second number given (24 in the case of the raw cotton yarn) indicates the number of thousands of yards in one pound.

hours. The adsorption samples were conditioned by drying over $Mg(ClO_4)_2 \cdot 3H_2O$ at 75° F. for two weeks. They were then placed quickly in the working chamber and successively brought to equilibrium at a series of increasing relative humidity values.

"Dry" Weight of the Fibres

The "dry" weights of the samples used in the desorption experiments were obtained after the completion of the series of experiments by heating the samples in an air oven at 212° F. overnight.

The "dry" weights of the samples used for the adsorption experiments were obtained prior to the experiments in the working chamber. Since heating in an air oven at 212° F. might have rendered the samples unfit for tests at lower temperatures, they were dried by suspending them from a wire passing through narrow glass tubing in the stopper of the bottle containing the drier. This made it possible to weigh the sample without removing it from the air over the drier. The samples required two weeks to reach constant weight.

The samples thus dried had a "dry" weight a little lower than those dried in the air oven at 212° F. (the relative humidity in the oven was from 1.5% to 2.0%). The differences for the various fibres averaged: for raw and "purified" cotton 0.15%; for clothing wool, carpet wool, viscose rayon and cuprammonium rayon 0.30%; for mercerized cotton and raw silk 0.20%; and for degummed silk and acetate 0.10%. All desorption data were corrected by these amounts. Thus, the moisture contents given in this report are based upon the weight of the material as dried over the chemical drier. They are expressed as percentage of the dry weight of the material. In the textile industry this is termed "regain."

No attempt is made here to differentiate between "free" and "bound" water in textiles or to discuss the merits of such a differentiation. It is realized that the term "dry" may have several connotations, varying from the exceedingly dry condition achieved by keeping materials in sealed tubes over an efficient drying agent for periods of several years, to a superficial drying, commonly described as "bone-dry," achieved by drying in an air oven maintained at or slightly above the boiling point of water, but open to the prevailing atmospheric humidity, which, as this report shows, results in a failure to remove from 0.1% to 0.3% of the adsorbed moisture.

Results and Conclusions

In Figs. 1 to 10 are curves of the familiar form expressing the relation between per cent. moisture content and per cent. relative humidity for each temperature and each material. Each point on the curves is the average of two determinations. The broken lines show extrapolated values. This extrapolation is quite justifiable since the relation between per cent. moisture content and per cent. relative humidity is linear in the range 10% to 60% relative humidity.

These curves indicate the limits in moisture content which may be expected in any of the textile fibres if the atmosphere in contact with the fibre during drying is maintained at any desired temperature and relative humidity. The "desorption" curve for the given temperature is to be used if the fibre is initially wet, and the "adsorption" curve if the fibre is

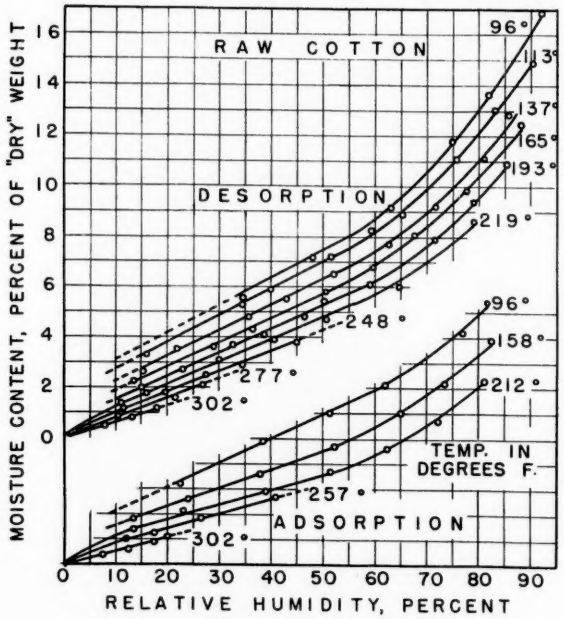

Fig. 1. The equilibrium moisture content of raw cotton yarn at different relative humidities and temperatures.

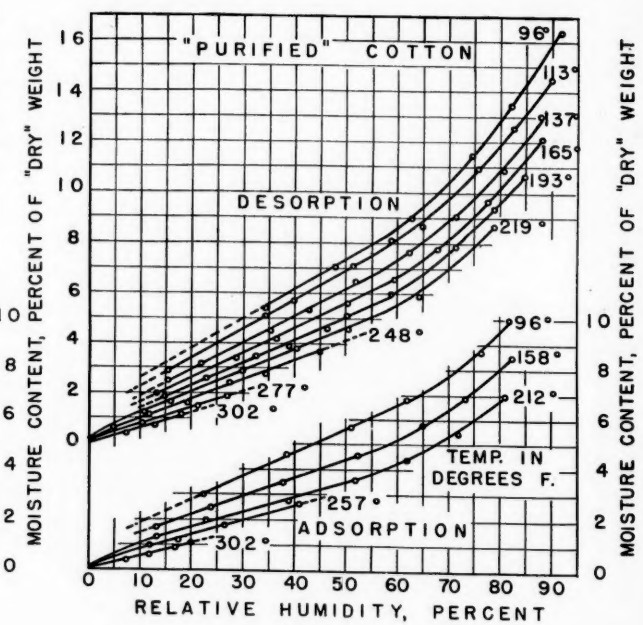

Fig. 2. The equilibrium moisture content of "purified" cotton yarn at different relative humidities and temperatures.

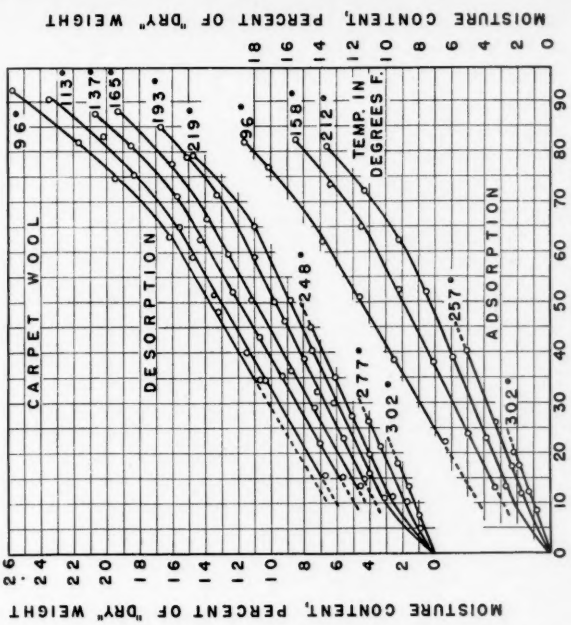

Fig. 4. The equilibrium moisture content of carpet wool yarn at different relative humidities and temperatures.

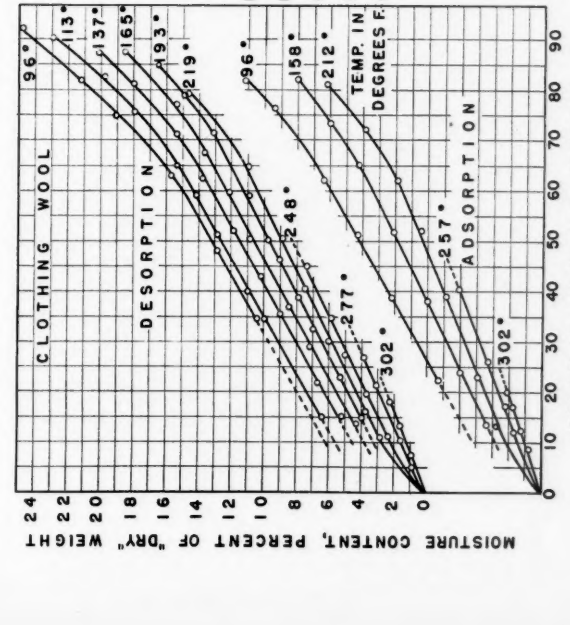

Fig. 3. The equilibrium moisture content of clothing wool yarn at different relative humidities and temperatures.

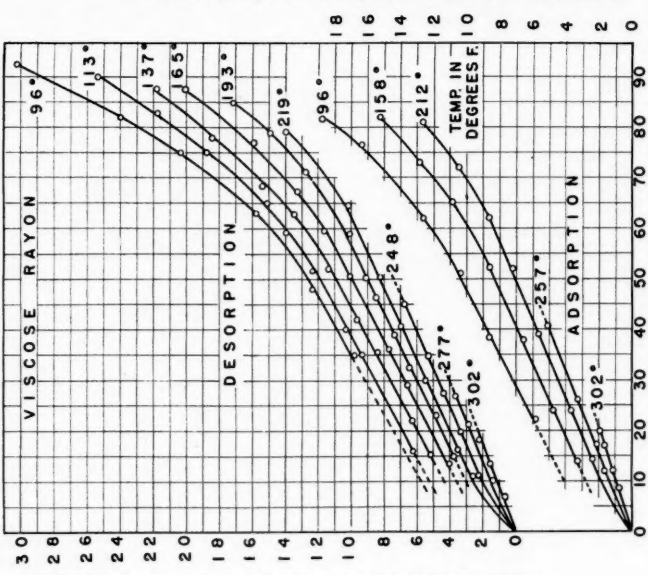

Fig. 6. The equilibrium moisture content of viscose rayon yarn at different relative humidities and temperatures.

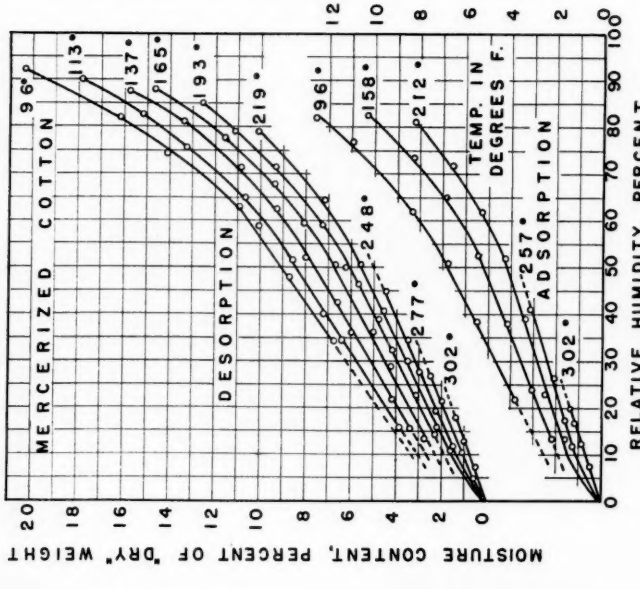

Fig. 5. The equilibrium moisture content of mercerized cotton yarn at different relative humidities and temperatures.

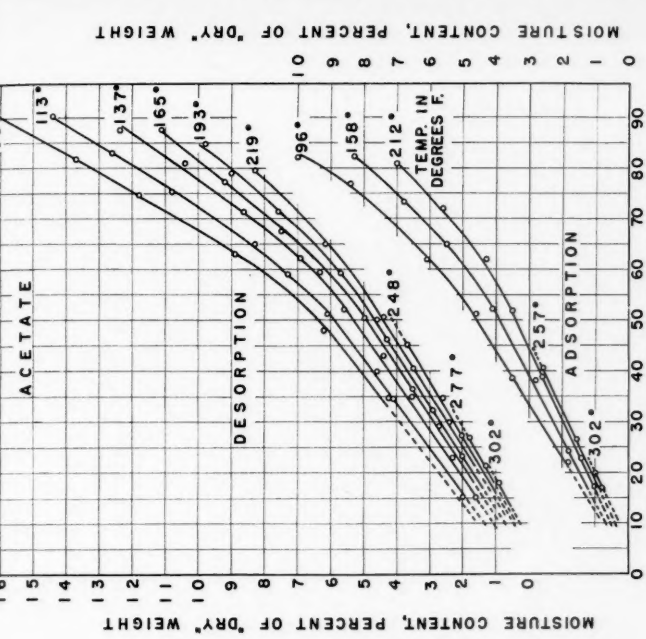

Fig. 8. The equilibrium moisture content of cellulose acetate yarn at different relative humidities and temperatures.

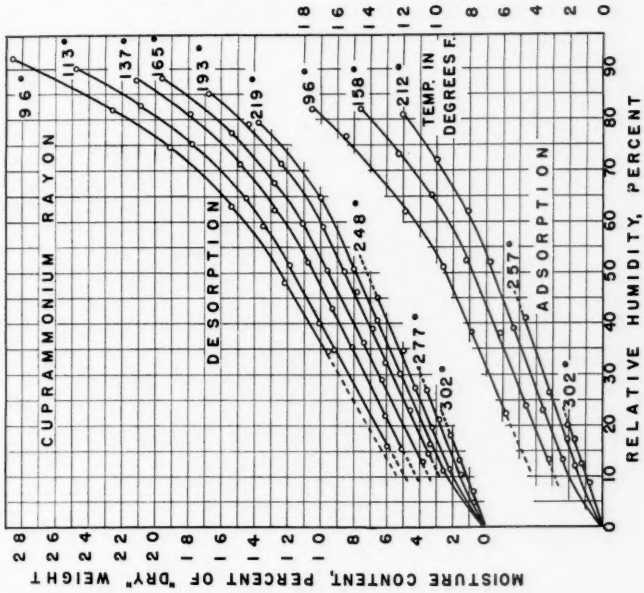

Fig. 7. The equilibrium moisture content of cuprammonium yarn at different relative humidities and temperatures.

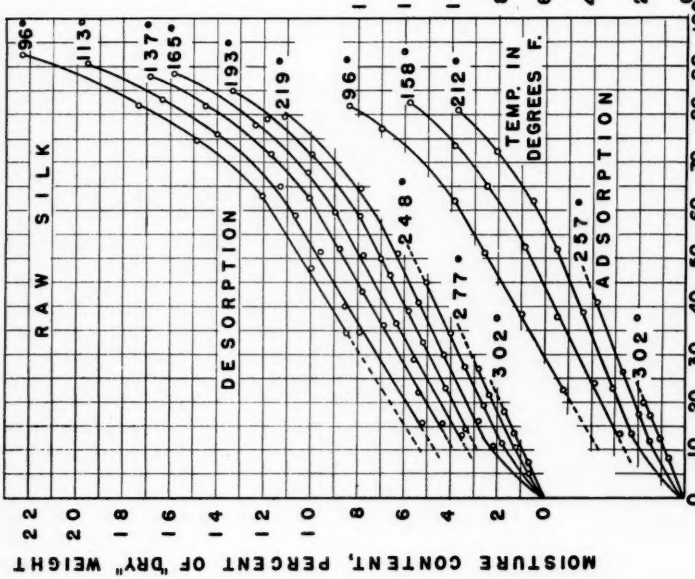

Fig. 9. The equilibrium moisture content of raw silk yarn at different relative humidities and temperatures.

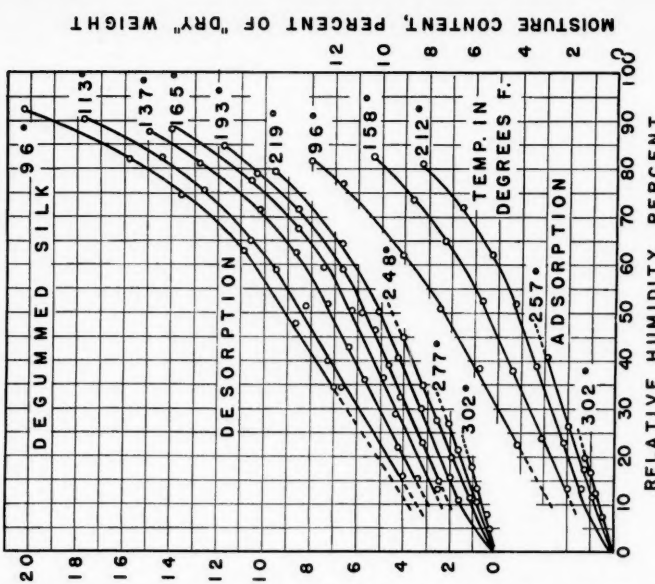

Fig. 10. The equilibrium moisture content of degummed silk yarn at different relative humidities and temperatures.

yarn at different relative humidities and temperatures.

Fig. 10. The equilibrium moisture content of degummed silk yarn at different relative humidities and temperatures.

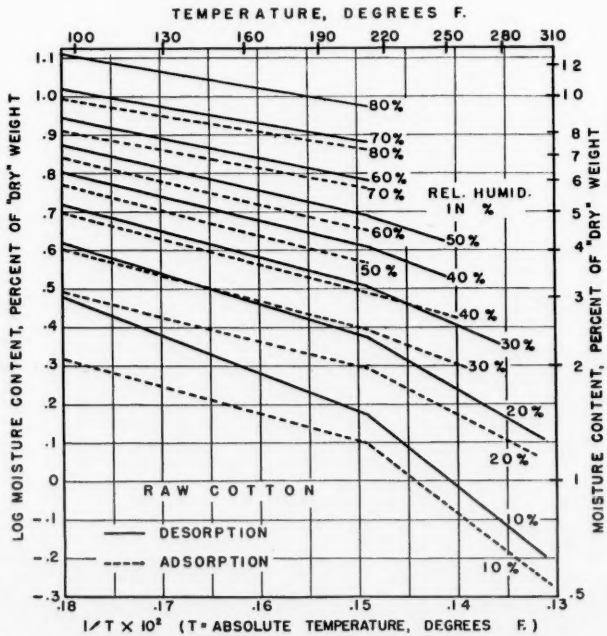

Fig. 11. The logarithm of the equilibrium moisture content of raw cotton yarn in relation to the reciprocal of the absolute temperature (1/T).

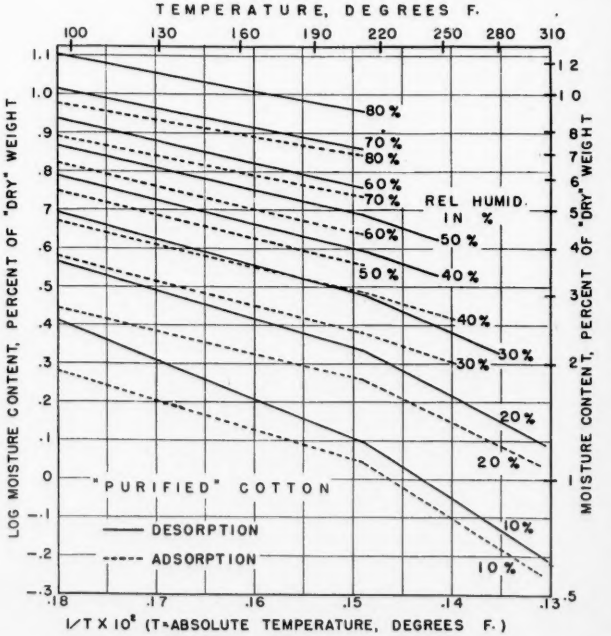

Fig. 12. The logarithm of the equilibrium moisture content of "purified" cotton yarn in relation to the reciprocal of the absolute temperature (1/T).

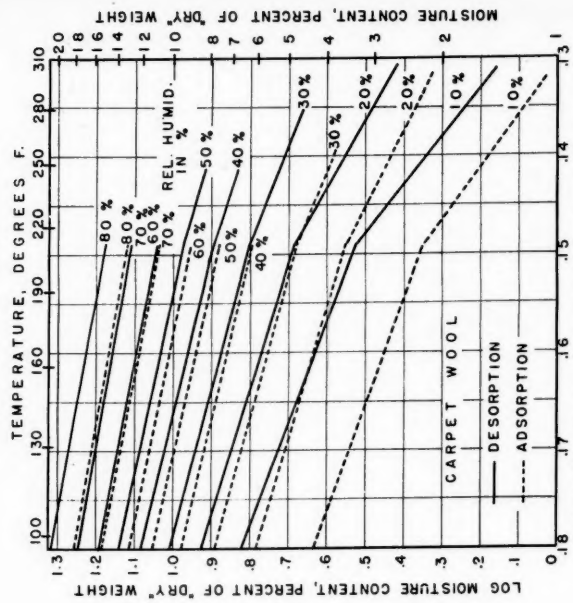

Fig. 14. The logarithm of the equilibrium moisture content of carpet wool yarn in relation to the reciprocal of the absolute temperature (1/T).

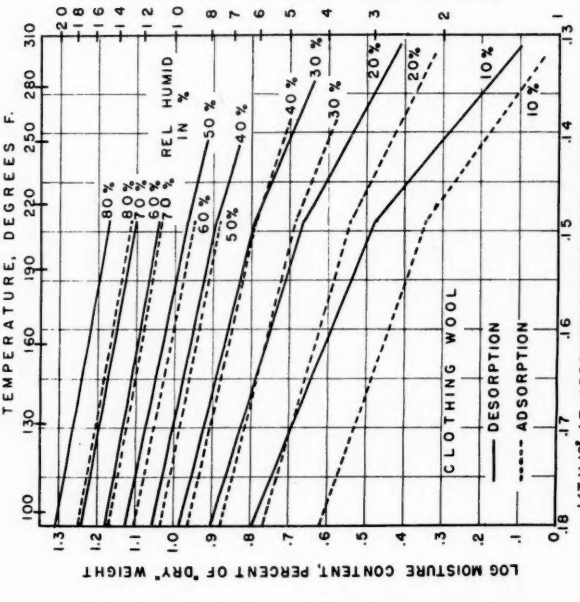

Fig. 13. The logarithm of the equilibrium moisture content of clothing wool yarn in relation to the reciprocal of the absolute temperature (1/T).

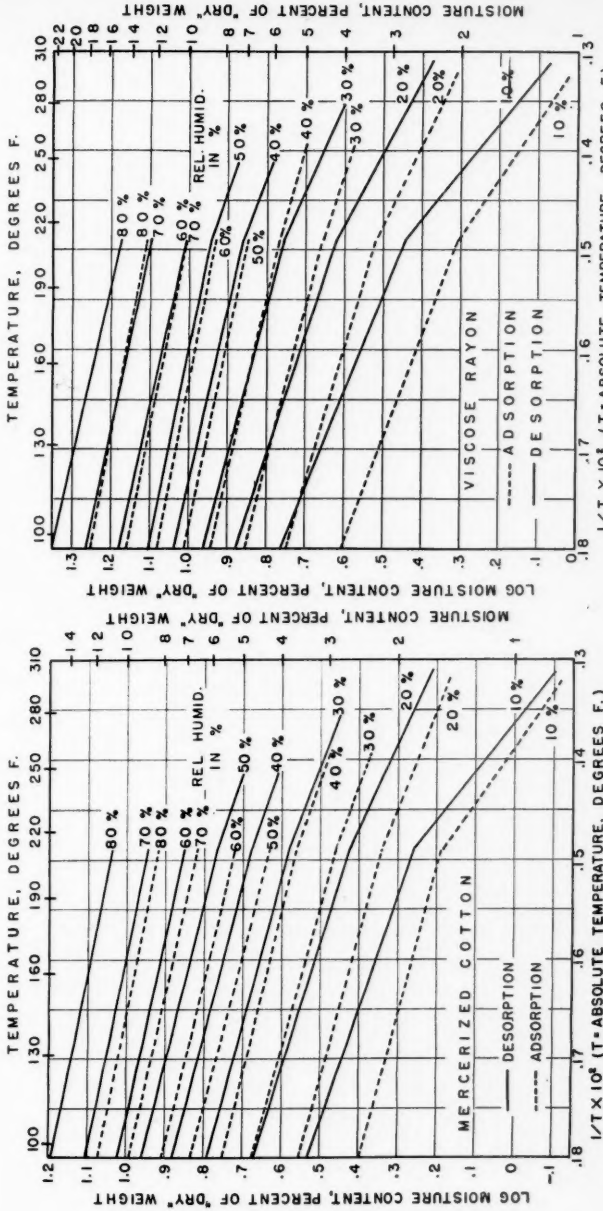

Fig. 15. The logarithm of the equilibrium moisture content of mercerized cotton yarn in relation to the reciprocal of the absolute temperature (1/T).

Fig. 16. The logarithm of the equilibrium moisture content of viscose rayon yarn in relation to the reciprocal of the absolute temperature (1/T).

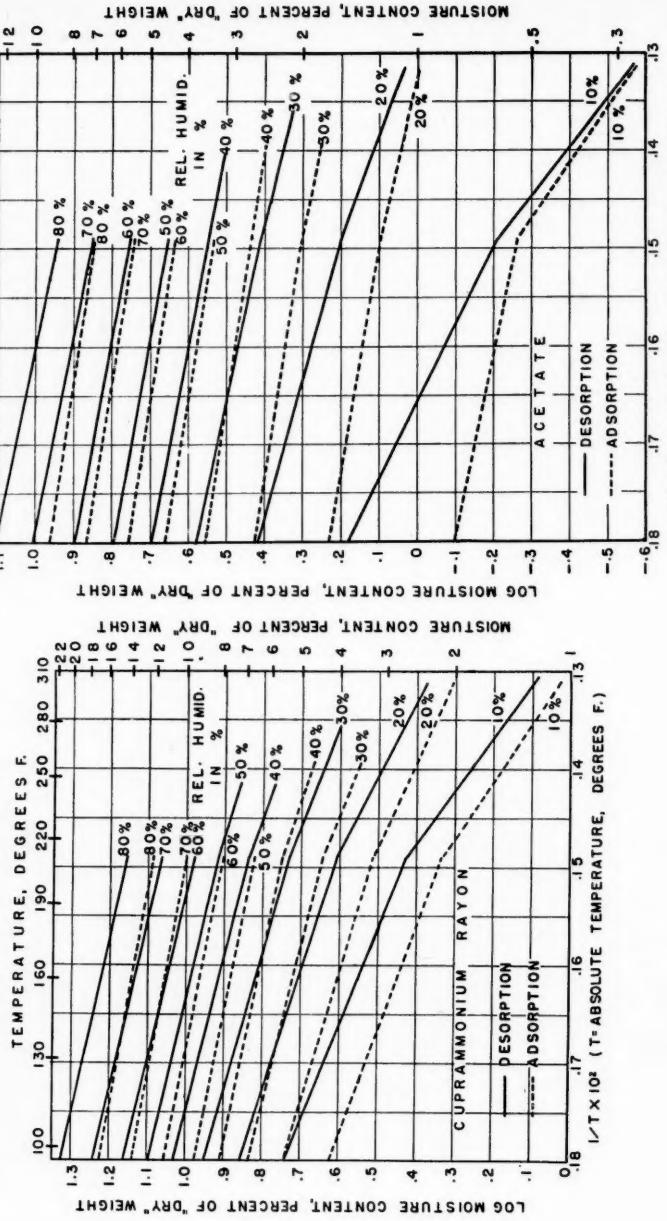

Fig. 17. The logarithm of the equilibrium moisture content of cuprammonium rayon yarn in relation to the reciprocal of the absolute temperature (1/T).

Fig. 18. The logarithm of the equilibrium moisture content of cellulose acetate yarn in relation to the reciprocal of the absolute temperature (1/T).

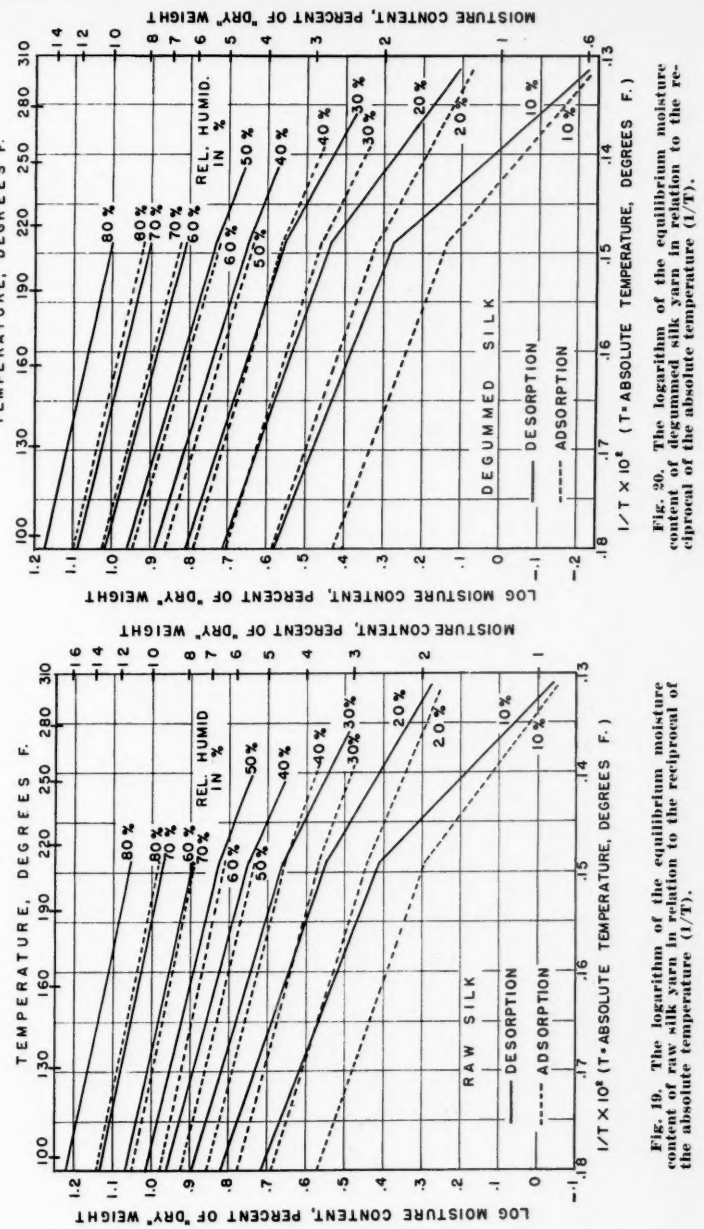
TEMPERATURE, DEGREES F.
100 130 160 190 220 250 280 310
REL. HUMID. IN %
80 % 80 % 70 % 70 % 60 % 60 % 50 % 50 % 40 % 40 % 30 % 30 % 20 % 20 % 10 % 10 %
DEGUMMED SILK
DESORPTION
ADSORPTION
LOG MOISTURE CONTENT, PERCENT OF "DRY" WEIGHT
MOISTURE CONTENT, PERCENT OF "DRY" WEIGHT
1/T × 10⁴ (T=ABSOLUTE TEMPERATURE, DEGREES F.)

Fig. 20. The logarithm of the equilibrium moisture content of degummed silk yarn in relation to the reciprocal of the absolute temperature (1/T).

TEMPERATURE, DEGREES F.
100 130 160 190 220 250 280 310
REL. HUMID IN %
80 % 80 % 70 % 70 % 60 % 60 % 50 % 50 % 40 % 40 % 30 % 30 % 20 % 20 % 10 % 10 %
RAW SILK
DESORPTION
ADSORPTION
LOG MOISTURE CONTENT, PERCENT OF "DRY" WEIGHT
MOISTURE CONTENT, PERCENT OF "DRY" WEIGHT
1/T × 10⁴ (T=ABSOLUTE TEMPERATURE, DEGREES F.)

Fig. 19. The logarithm of the equilibrium moisture content of raw silk yarn in relation to the reciprocal of the absolute temperature (1/T).

initially dry. It should be emphasized that the curves apply, of course, only to the samples examined. Further work is necessary to determine what variation is to be expected in different lots of the same fibre, or when the fibres contain impurities such as oils, sizing materials, and dyes.

A study of these data revealed that if the logarithms of the moisture contents at any fixed relative humidity are plotted against the reciprocals of the corresponding absolute temperatures (1/T), straight line relationships are obtained with changes in the slopes of the lines between 200° F. and 220° F. The slope of the "desorption" line thus obtained gives the rate of *decrease* in equilibrium moisture content of a textile, with *increasing* temperature, at constant relative humidity. The slope of the "adsorption" line gives the rate of *increase* in equilibrium moisture content, with *decreasing* temperature, at constant relative humidity. Thus, a series of such linear relations may be prepared, one for each relative humidity, from which it is possible to ascertain the moisture content for any humidity at any temperature within the range investigated. Since Urquhart and Williams * obtained similar data on cotton including temperatures as low as 50° F., and the relation holds for their data as well as for those presented here, it seems reasonable to assume that the linear relation may be extrapolated down to temperatures somewhat below room temperature if desired.

Figs. 11 to 20 show these relations for humidities at 10% intervals between 10% relative humidity and 80% relative humidity. The unbroken

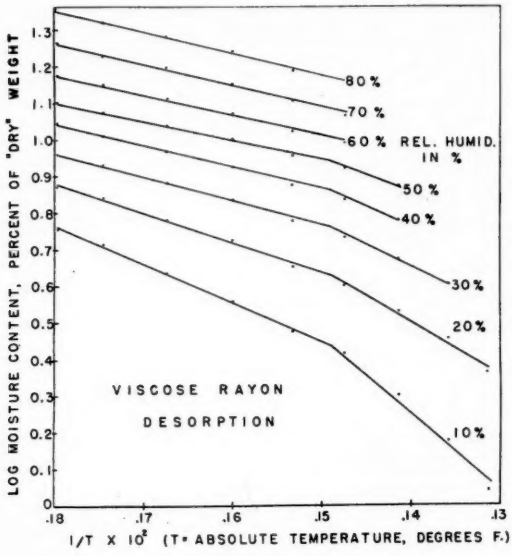

Fig. 21. The logarithm of the equilibrium moisture content of viscose rayon yarn in relation to the reciprocal of the absolute temperature (1/T).

* Urquhart and Williams. *J. T. I.*, *15*, T559–572 (1924).

lines give this relationship for the desorption data, the broken lines for the adsorption data. The data for these graphs were taken from the curves given in Figs. 1 to 10 and are not represented as points on these graphs in order to avoid confusion between the adsorption and desorption curves. An average example of how closely the logarithms of the moisture contents follow a linear relationship with the reciprocals of the corresponding absolute temperatures is shown by Fig. 21, which gives the desorption data for viscose rayon.

Examination of Figs. 11 to 20 shows that the linear relationships obtained give changes in the slopes of the lines between 200° F. and 220° F. The data are represented for convenience by straight lines but could be better fitted by a smooth curve. The bending of these curves is of significance in connection with heats of swelling, but the theoretical analysis has not yet been carried out.

Certain generalizations may be made for all the textiles examined. Above 30% relative humidity the slope of the linear relation changes very little with increasing humidity, in the range between 100° F. to 200° F. Below 30% relative humidity the slope increases appreciably with decreasing humidity. Above 200° F. the slopes change for all relative humidities investigated up to 50%.

Acknowledgment

Acknowledgment is made to Dr. A. C. Walker, chairman of the Administration Committee for Drying Research, United States Institute for Textile Research, for suggesting the treatment of the data used in this report and other valuable advice.

(*Continued from page 356*)

* Taylor Instrument Companies, Rochester, N. Y.; *** Tennessee Eastman Corp., Kingsport, Tenn.; *** Tubize Chatillon Corp., New York, N. Y.

* United Merchants & Mfrs. Mgmt. Corp., New York, N. Y.; *** U. S. Hoffman Machinery Corp., New York, N. Y.; ** U. S. Testing Co., Inc., Hoboken, N. J.; *** Uxbridge Worsted Co., Uxbridge, Mass.

** Wyandotte Worsted Co., Waterville, Maine.

NOTE. * Subscribed for one year. ** Subscribed for two years. *** Subscribed for three years.

Viscose Rayon: Stress-Strain Properties

III. Effect of Relative Humidity

By H. R. BELLINSON *

A Textile Foundation Publication

Summary

Measurements were made of the strength and stretch of viscose rayon yarns at values of relative humidity ranging from 43 to 74%.

It was found that the strength decreases and the stretch increases as the relative humidity is increased. Both effects are approximately linear in the region observed. The change in strength is 2.58 grams, in stretch .047%, for each 1% change in relative humidity.

Stretch-load diagrams are shown, and it appears there that the "yield" region decreases and the "work hardening" region increases with increased relative humidity.

Correlation is found to exist between strength and stretch of individual specimens. The best estimate of the coefficient of correlation is + 0.185.

Introduction

BEFORE beginning an investigation into the physical properties of viscose yarns, it is essential to discover how those properties vary as the testing conditions are changed. In one sense, of course, these variations are in themselves physical properties of the material, but knowledge of such changes with testing conditions is required in order to design and interpret properly more complicated experiments. In two previous papers,[12, 13] the effects of specimen length and rate of loading on the stress-strain properties of viscose yarn were discussed. The effect of varying the relative humidity of the atmosphere with which the yarn is in equilibrium is discussed in the present paper.

Testing

The experiments described here were performed on an inclined plane testing machine. This machine was described in a previous paper.[12] Its great advantage is that the rate of loading is constant throughout any one

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test and from test to test. In the present series of tests, the rate of loading was 6.04 grams per second.

The material tested was viscose rayon 150/42, manufactured by the North American Rayon Corporation. All specimen lengths were 20 in.

Conditioning.—The tests were performed in an air-conditioned laboratory in which both temperature and humidity were controlled, and in which the air was circulated by a blower system. The temperature was held at 70° F. $\pm$ 0.5°, except for the tests above 70% R.H., where the temperature was 72° F. The relative humidity was constant for each set of tests to $\pm$ 1% R.H.

Tests were made in the order of increasing relative humidity (each set of tests was completed before the relative humidity was altered), and specimens were given approximately two days in which to come to equilibrium with the atmosphere before being tested.

Sampling.—The specimens were taken from three skeins of yarn. These three skeins were taken in succession from a cone of rayon, each skein was cut open, thus providing 80 strands, and from each skein 10 strands were taken at random to be tested at each value of the relative humidity. In this way, differences in the yarn were randomized over the groups, so that significant changes in properties can be associated with changes in relative humidity only.

TABLE 1

Results: Set F.

Relative Humidity	Strength		Breaking Stretch		Number of Specimens
	Average	Standard Deviation	Average	Standard Deviation	
43%	325.3 gm.	5.75 gm.	21.60%	0.67%	28
57	290.4	5.85	22.62	0.57	30
65	268.1	5.52	22.94	0.61	30
74	245.7	3.44	23.01	0.53	30

Discussion

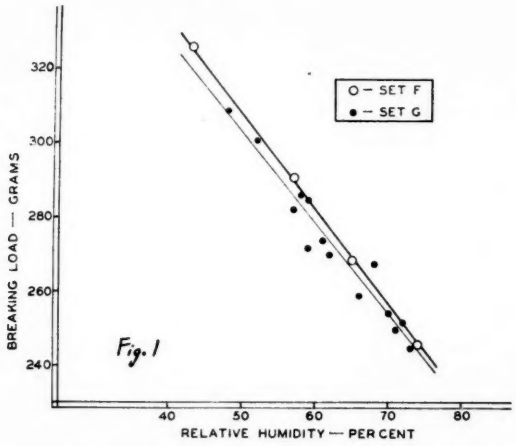
Strength.—When examined by the statistical technique of Analysis of Variance,[3] the differences in strength are found to be overwhelmingly significant. There can be no doubt that these differences are real, and not due to sampling fluctuations. The values of strength are plotted against relative humidity in Fig. 1. It is apparent that differences are associated with relative humidity (the coefficient of correlation is — 0.98), and that the effect of relative humidity is practically linear. The straight line obtained by the method of least squares[4] is

$$S = 436.6 - 2.58\ R$$

S being the average strength in grams, and R the relative humidity in per cent. The fit of the observed points to this line is exceedingly good.

The four values of standard deviation were examined by Pearson and Neyman's L_1 test.[5, 6, 7] The probability of obtaining four values differ-

ing as much as these by accident is between 0.05 and 0.01. It thus appears that the differences are rather large. However, it should be noted that the first three values are practically identical, and that all the difference is introduced by the low value of standard deviation obtained at 74% R.H. It was found, on examining the records, that whereas the relative humidity had varied $\pm 1\%$ for the first three tests, the variation had been only $\pm 0.5\%$ for this test at 74% R.H. And since relative humidity affects strength, the results of more constant atmospheric conditions would be, as found, a lower value of the standard deviation.



The expected effect can be approximated quantitatively. Assuming that the values of relative humidity occur uniformly over the observed range (*i.e.*, have a rectangular distribution), then the variance (square of the standard deviation) contributed by the varying relative humidity would be the square of the range divided by twelve. The range is the limiting effect produced on strength. Since a change in relative humidity of 1% changes the strength by 2.58 grams, the range corresponding to humidity control of $\pm 1\%$ is 5.16 grams. The component of variance is thus 2.22. The observed variance at 65% R.H. is 30.47, *i.e.*, $(5.52)^2$. Subtracting 2.22, and taking the square root, the corrected standard deviation, measuring variability at constant relative humidity, is found to be 5.31 grams. The value at 74% R.H., similarly corrected, is 3.36 grams.

Obviously, the effect of varying relative humidity is much too small to account for the low standard deviation at 74% R.H. In addition, it was assumed that the yarn is in instant equilibrium with the changing atmosphere. This is unlikely; there is probably a lag between a change in atmospheric moisture and a corresponding change in strength. Such a lag would tend to average out small changes in strength, and would make the actual effect of variations in relative humidity on the standard deviation even smaller than computed.

A probability between 0.05 and 0.01, as found above, is not generally considered sufficiently small to prove the existence of a real difference apart from sampling fluctuations. It is usually interpreted as suggesting that such a real difference may be present, and that further tests are indicated. So, in this case, it can only be said that perhaps, as the relative humidity goes up, the variation in strength from one specimen to the next tends to decrease. The point requires further investigation, particularly at humidities higher than those reached here, since the effect seems to be absent below 65% R.H.

Breaking Stretch.—As in the case of strength, the differences in breaking stretch of Table I are undoubtedly significant. The values are plotted against relative humidity in Fig. 2, and it is apparent that the changes in

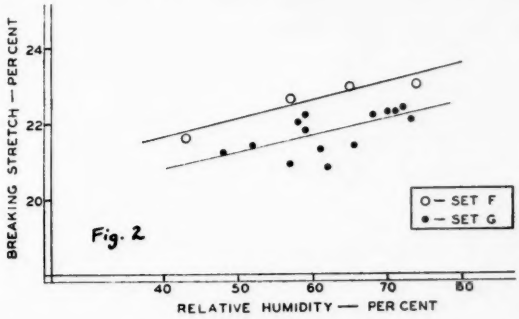


Fig. 2

stretch are associated with the changes in relative humidity (the coefficient of correlation is + 0.65). The straight line obtained by the method of least squares is

$$E = 19.77 + 0.047\ R$$

where E is the average breaking stretch in per cent., and R the relative humidity, also in per cent. However, the points do not fit the straight line as well as in the case of strength. When examined by the Analysis of Variance,[8] it is found that deviations as large as those observed from the straight line can be expected in less than one such test out of a hundred.[9]

The parabola

$$E = 14.41 + 0.238R - 0.00164\ R^2$$

is very nearly a perfect fit. However, the question as to whether the effect is linear or curved cannot be answered satisfactorily on the basis of observations at only four values of relative humidity. A parabola can be found to fit any three points, and in this case there is only one additional point.

The values of standard deviation do not differ significantly.

Regain.—The effect upon the properties of the yarn is not directly caused by the change in relative humidity of the surrounding atmosphere, but rather by the changes in moisture regain of the yarn resulting from the changed relative humidity. Urquhart and Eckersall [1] measured the regain

TABLE 2

Analysis of Variance: Breaking Stretch.

Source of Deviations	Sum of Squares	Degrees of Freedom	Variance
Straight line	32.465	1	32.465
From line	3.969	2	1.984
Residual	40.381	114	.354
Total	76.815	117	

$Z = .862$ $P < 0.01$

of viscose at various relative humidities, and found that the curve of regain vs. relative humidity was practically linear from 20 to 70% R.H. The complete curve is sigmoid shaped, and is similar to the curves for other cellulose materials. For high values of the relative humidity, the line curves upward to higher values of regain; and for low values of relative humidity, the line curves downward to zero regain. But at the intermediate value of relative humidity (approximately 20 to 70%) the line is almost straight.

In the present tests, relative humidity was varied from 43 to 74%. The conditioning system could not be made to reach higher or lower values at the same temperature. Throughout this region the regain is a linear function of relative humidity, and the fact that strength and stretch are also approximately linear with the relative humidity can be taken as indication that strength and stretch are approximately proportional to the regain. In that case, the curves of Figs. 1 and 2 must not be extrapolated below 20% and above 75% R.H., since in those regions the regain is no longer proportional to the relative humidity. Peirce,[2] measuring the rigidity of cotton hairs as a function of relative humidity, found that from 10 to 70% R.H. the relation was approximately linear, but that outside of this region, the line curved in opposite directions, as in the sigmoid curve for regain vs. relative humidity. A similar situation might be expected to occur in the case of strength or stretch as a function of relative humidity. As a matter of fact, the actual values for wet yarns (100% R.H.) are about 140 grams strength and 36% breaking stretch, whereas values obtained by extrapolating the straight lines of Figs. 1 and 2 are 180 grams and 24.5%, and so are wrong by a considerable margin.

Set G.—The points marked Set G in Figs. 1 and 2 represent another set of tests made upon the same rayon. Here tests were made at smaller intervals of relative humidity, but only three specimens were tested in each group. All specimens were taken from a single skein, which was taken from the same cone, but at a different position, from the skeins of Set F.

The averages are plotted on Figs. 1 and 2 as solid circles, along with the least squares fit straight lines:

$$S = 423.7 - 2.43\ R$$
$$E = 19.02 + 0.044\ R$$

These equations differ from those obtained for set F both in the constant terms and in the factors of R. However, when examined statistically,[10]

it was found that for neither strength nor stretch is the difference in the factor of R between the two sets significant; that is, differences of the magnitude observed are to be expected in samples of the size measured. The effect of relative humidity, which is measured by the factor of R in these equations, is therefore constant within the limits of sampling error. The constant terms of the equations may differ significantly, but that merely indicates that the strength (or stretch) of Sets F and G are not precisely the same, and since the two sets are taken from different portions of a cone, this is not unreasonable.

The points of Set G appear to be poor fits to the lines of the two figures. However, the reason these points lie so far from the line is not that they fit poorly, but because they are averages of only three tests each. As a result, the sampling fluctuations of these averages can be expected to be large, and points will scatter widely about their true values, as they actually do in the plots.

Correlation: Strength and Stretch.—In a previous paper,[12] an attempt was made to discover whether correlation existed between the breaking strength and stretch of individual specimens of viscose yarn. At that time, it was concluded that the coefficient of correlation was probably less than + 0.28, but that there was insufficient data to prove the significance or existence of correlation. Now, correlation coefficients were computed for the four groups of tests in Set F (Table 3).

TABLE 3

Coefficient of Correlation:
Breaking Strength and Stretch.

Relative Humidity	Correlation
43%	+0.396
57%	+0.337
65%	+0.113
74%	+0.230
Average	+0.270

The average, r = + .270, is significant—a value this large could be expected to occur only four times in a thousand tests if there were no correlation. In the previous paper, the average was + 0.132. The difference in averages is not significant. Further, if the four group values of that paper are considered together with the four group values of Table 3, then it is found that the eight values do not differ significantly among themselves.[11] Consequently, it is proper to combine the eight values to obtain a single and most reliable average.

This average is r = + 0.185. This is significant; it could occur only once in a thousand tests as a sampling fluctuation. Therefore, it must be accepted that positive correlation exists between breaking strength and breaking stretch in individual specimens of viscose yarn; the coefficient of correlation is probably between + 0.127 and + 0.243.

Stress-Strain Diagram.—The inclined plane machine continually records the values of stretch at every value of load. Thus, a load-stretch diagram is available for every specimen tested. Average diagrams may be obtained

by reading off the chart values of stretch for chosen values of load (since load is the independent variable in this apparatus), and averaging the values of stretch for all the specimens of a group. Average curves so obtained are plotted in Fig. 3.

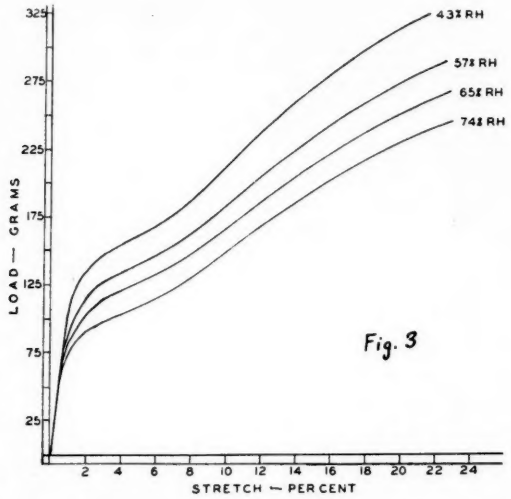


Fig. 3

The load-stretch diagram of viscose shows three characteristic regions:

(1) "Elastic" region (in which stretch is proportional to load); the line is straight.
(2) "Yield" region (at which stretch begins to increase); beginning of curvature.
(3) "Work hardening" region (in which the yarn flows and is permanently distorted); the line slopes more and is not straight.

Moisture appears to affect all three of these regions.

Measurements of the slope of the elastic region result in the averages of Table 4. There appears to be a change in this slope as the regain of the viscose changes. However, no great weight should be put on these figures. The actual stretch at 50 grams load (20 in. specimens) is ten times the fig-

TABLE 4

Slope of "Elastic" Region.

Relative Humidity	% stretch/gram load
43%	.0086
57	.0091
65	.0101
74	.0107

ures of Table 4 in inches. The difference in stretch at 50 grams between 43% R.H. and 74% R.H., is only .023 in. This is of the same order of magnitude as the thickness of the line drawn by the recording pen. It is true that each of the values in the table is the average of some 30 tests, but their significance cannot be proven. The tests performed are known to be insensitive to changes in the elastic region, but the data is reported because the apparent change in slope is consistent with the changes in relative humidity, and in the thought that the figures may stimulate a more careful investigation with properly designed apparatus.

However, there can be no doubt as to the effect of moisture on the other two regions of the curves. The "yield" region decreases as the regain increases. It is not possible to measure the point precisely; the change from "elastic" region to "work hardening" region is gradual, and the point at which the curve begins to depart from the straight line is difficult to define. However, from examination of Fig. 3, it appears that the change in the point is of the same order of magnitude as the change in breaking strength.

Further, as the regain increases, the slope of the "work hardening" region decreases—that is, plastic flow increases and is easier to induce at higher moisture regains.

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Electrodialytic Estimation of Ash and of Acidic and Basic Groups in Textile Fibres

By ARNOLD M. SOOKNE, CHARLES H. FUGITT, and JACINTO STEINHARDT *

A Textile Foundation Publication

Abstract

Considerable practical interest attaches to the ash of textile fibres. It is well known, for example, that the electrical properties of textiles such as cotton, silk, and wool depend to a considerable extent upon the nature and amount of inorganic substances in the fibres. In addition, this ash content influences the uptake of moisture and dyestuffs, as well as the ability of the fibre to combine with certain softening or finishing agents.

The method of combustion usually employed for the estimation of the ash yields results which acquire significance in terms of equivalents only when an estimate of the composition of the ash can be made. Since the ash may contain substances, such as sulfate in the case of wool, which are not in the unburned fibre, but which are formed during the combustion process, its composition is uncertain at best.

It is shown by recent work of the research associates of the Textile Foundation at the National Bureau of Standards that the hydrogen-ion equivalence of the cationic ash of fibres (the total content of the cations of bases whether free, or combined with acids, or with the acid groups of the fibres) may be obtained directly, without ignition, by existing electrodialytic procedures which have been hitherto applied principally to biological solutions. Only simple and inexpensive equipment is required. The content of any given anion in the sample may be similarly determined. By duplicating the procedure on a larger scale, the method has been used to obtain samples of fibrous materials of very low ash content. A simple extension of the method which permits the quantitative determination of the acidic and basic groups in the material consists in combining them with suitable tightly bound cations or anions which are subsequently estimated by the electrodialytic procedure.

Examples are given of the application of the method to dewaxed and to depectinized cotton. In both cases the results are shown to correspond with the capacity of the fibres to bind acid.

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Examples are also given of ash determinations on wool fibres and on samples of wool cloth at several stages in processing subsequent to the carbonizing process. A comparison of the results with the ash obtained gravimetrically on similar samples, after combustion, permits the estimation of the average equivalent weight of the constituents of the ash, and aids in their identification. It is shown that the largest part of the ash of untreated wool, as obtained by combustion, consists of sulfates. Since sulfates are not present to an appreciable extent in washed (defatted) root-wool fibres, the presence of this anion in the ash of such fibres must be attributed to the oxidation of the sulfur of the wool during combustion. The much larger ash remaining after carbonizing, neutralizing, and rinsing is also in the form of sulfates, but at these stages most of the sulfate has been contributed by the sulfuric acid in the carbinizing process.

I. Introduction

CONSIDERABLE practical and theoretical interest attaches to the estimation of the ash of textile fibres. The method of combustion, usually employed, is time-consuming and yields values which acquire significance in terms of equivalents only when an estimate can me made of the composition of the igneous residue. In addition, this method may sometimes give values which do not accurately represent the inorganic constituents in the unburned fibre. Thus, the ignition of wool results in the formation of sulfate from the oxidation of part of the organic sulfur of the amino-acid, cystine, which constitutes an appreciable part of this protein. Consequently the ash of wool is heavier than it would be if all of the inorganic bases combined with it were found as carbonates or oxides.

The method of electrodialysis used by Joseph and Stadie [1] for the determination of total cations and chloride in blood, has been found to be of value for the estimation of the equivalence of the cationic ash of textile fibres (the term cationic ash in this paper signifies the total content of the cations of bases, whether free, or combined as salts of acids or of the acid groups of the fibres.* This method permits the direct estimation of the hydrogen-ion equivalence of the cationic ash; in addition, it may be extended to include the estimation of specific anions, such as sulfate, which are important in the control of textile finishing processes. Unlike the combustion method, electrodialysis has preparative as well as analytical value, since the samples used in analysis may be recovered, freed of most of their ash, at the end of the determination.

Besides describing the procedure which may be employed with a number of textile fibres and demonstrating the accuracy of the results obtained, the present paper also suggests simple extensions of the procedure which render it applicable to the direct determination of the acidic and basic groups of a wide variety of materials, including fibres.

II. Method

In the present investigation, the method of Joseph and Stadie was followed with two modifications: (a) The addition of dilute acid to the

* The term is equivalent to the conventional expression "total base" used by Joseph and Stadie in the paper cited, and by biochemists generally.

sample to be dialyzed aided in the liberation of cations combined with the fibres, and greatly shortened the time required for their recovery at the cathode; (b) The formation of a reliable seal between the Cellophane membranes and the sides of the dialysis tubes was considerably expedited by the substitution of a commercial cellulose nitrate cement,* for the collodion employed by Joseph and Stadie. A diagram of the apparatus employed, copied from the original article, is given in Fig. 1. The application of a

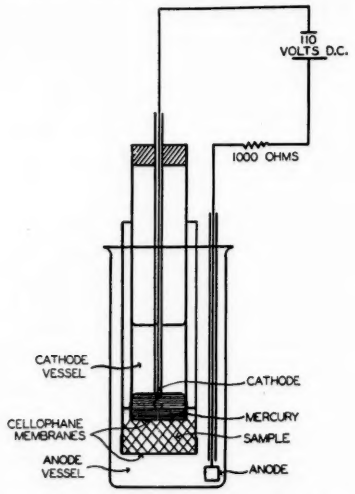

Fig. 1. Diagram of electrodialysis apparatus.

potential difference across the electrodes brings about the migration of cations to the mercury cathode, where they are discharged and form amalgams. Subsequent mixing of the amalgam with the standard solution of hydrochloric acid above the mercury causes a reduction in its titer which corresponds to the hydrogen ion equivalence of the cationic ash. The titers of the original and final solutions were measured with a 0.02 *M* solution of sodium hydroxide, using bromeresol purple as the indicator. When chloride is among the anions present, it is discharged at the anode unless, as in Joseph and Stadie's method, a suitable reducing agent is added to the anode chamber in order to prevent this. When sulfate is present, oxygen is evolved and sulfate accumulates in the anode chamber. The quantity of sulfate in the sample may then be determined gravimetrically by precipitation as barium sulfate.

In the method actually employed, a sample of purified cotton, wool, or silk weighing between 0.5 g. and 1 g. was placed in the sample chamber, and soaked in a dilute solution of hydrochloric acid for an hour, after which the sample was electrodialyzed for two hours. A resistance of 1,000 ohms in series with the electrodes gave an initial passage of current of about 100

* Duco cement, made by E. I. DuPont de Nemours & Company was employed.

milliamperes, which diminished rapidly as the removal of ions progressively raised the resistance of the dialysis chamber. The accumulation of bubbles of gas on the membranes is avoided by occasionally tapping the outer glass tube. With cotton, identical results for the cationic ash were obtained when 0.02 *M* or 0.15 *M* solutions of hydrochloric acid were used for the soaking treatment. Longer periods of electrodialysis did not appear to increase the effectiveness of recovery of the cationic ash of cotton. With wool, however, slightly more consistent results were obtained with longer initial periods of exposure to acid, and with the higher concentration of acid. Samples of cotton freed of inorganic ions by this treatment yielded no measurable igneous residue.

III. Results and Discussion

1. Cotton. The cationic ash is a factor of primary importance in the behavior of naturally-occurring cellulosic materials toward acids. Following the demonstration by McLean and Wooten that a linear relationship obtains between the contents of cationic ash and the acid-binding capacities of various cellulosic materials at an arbitrary pH,[2] Sookne and Harris have shown that the limiting amount of acid with which cotton can be made to combine at low values of pH corresponds to the hydrogen-ion equivalence of its cationic ash.[3] The results of electrodialytic analysis of cotton may therefore be compared directly with the results obtained by an independent method. Table 1 lists determinations of the cationic ash of a sample of

TABLE 1

The hydrogen-ion equivalence of the cationic ash of samples of dewaxed cotton

Weight of fibres, dry basis	Cationic ash	Cationic ash
g.	milliequiv.	milliequiv./g.
0.5065	0.0324	[a]0.0640
.5159	.0340	.0659
.5092	.0305	.0599
.5176	.0334	.0645
.5095	.0302	.0593
		Mean 0.0627

[a] Since the titer differences from which the data of these tables were computed had a precision of 1 part in 150, the data could be represented by either 2 or 3 significant figures. They are given to 3 figures to permit a better estimate of their reliability.

dewaxed cotton, the preparation of which has been described elsewhere.[2] The values given have been corrected by subtracting a blank of 0.0040 milliequivalent of acid, a value determined empirically by numerous control runs on the dilute acid solutions in the absence of fibres. Experience has shown that the major source of uncertainty in the first result is the extent to which the blank is reproducible. The mean of the values given is 0.0627 milliequivalent per gram of cotton, in good agreement with the value for the maximum acid-binding capacity of the same sample, 0.066 milliequivalent per gram [3] determined by direct titration.

The completeness of recovery of the cations was tested by adding 0.0200 milliequivalent of potassium chloride to weighed samples, identical with

those described above, before making the determinations. The results of these measurements are given in Table 2. The second column represents the

TABLE 2

The recovery by electrodialysis of potassium ion added to samples of cotton

Weight of fibres, dry basis	Total cationic ash	Cationic ash of cotton	K^+, recovered	K^+, added
g.	milliequiv.	milliequiv.	milliequiv.	milliequiv.
0.5106	0.0519	0.0320	0.0199	0.0200
.5115	.0523	.0321	.0202	do
.5129	.0525	.0322	.0203	do

recovery of cations, combined plus added; the third column lists the cationic ash of the cotton calculated from the weight of the sample and the value of 0.0627 milliequivalent per gram obtained in the preceding experiments. The recovery of *added* potassium, shown in column 4, is obtained by subtracting the figures of the third column from the corresponding figures of column 2. The resulting figures indicate very complete recovery of added potassium, and furnish strong evidence for the accuracy of the figures for the naturally-occurring cations.

2. Wool. The ash content of samples of wool from different sources may vary over wide limits. A large part of the cation content of wool is combined with the acidic groups of the protein (as $RCOO^- M^+$). Consequently, close agreement between measurements of the amounts of acid bound by wool protein in different lots of wool at any given pH may only be achieved by subtracting the hydrogen-ion equivalent of the combined cations in each lot of wool from all directly determined values of the acid bound under any given conditions.[4] Thus, a method is required for determining the equivalence of the ash rather than its weight percent, unless its composition is accurately known. Such a method, described in this paper, is also useful in wool processing, as for example in the control of neutralization and rinsing after the carbonization of wool.

Representative determinations of the ash of fibres, from two different sources, which had been extracted with alcohol and ether and washed with water are given in Table 3. It will be noted that longer intervals of time were employed than in the work with cotton. When appreciably shorter periods were allowed for soaking in acid, or for electrodialyzing, the resulting figures were lower and lacking in reproducibility. It has been shown that when wool is immersed in dilute solutions of acid the attainment of equilibrium requires much longer periods than when cotton fibres are similarly treated.[3, 4] The shorter times sufficing for cotton are probably due to the fact that the greater part of the combined cations of dewaxed cotton are associated with an outer shell of pectic substance which is more readily dissolved in dilute aqueous solutions than is the cellulosic part of the fibre.[3, 5, 6] The longer interval required for complete ionic recoveries in the electrodialysis of wool is probably a consequence of the same factors which delay its attainment of equilibrium with solutions of acid.

The empirical combining weights of the ash (milligrams of ash on ignition divided by milliequivalents of cations recovered on electrodialysis),

TABLE 3

The equivalence of the cationic ash in wool fibres
3 ml of 0.15 *M* HCl were added to approximately 0.5 g of wool

Time of preliminary soaking in acid	Time of passage of current	Cationic ash	Ash by combustion at 700° C	Empirical equivalent weight of ash
hours	hours	milliequiv./g.	mg/g.	g.
2.0	2.0	0.035	2.60	74.2
2.0	2.0	[a].029	do	89.5
2.0	3.5	.037	do	70.3
1.5	4.3	.036	do	72.2
3.0	3.0	.036	2.75	76.3
3.0	3.0	.151	11.4	75.5

[a] In the course of this measurement, it was observed that the passage of current was impeded by the accumulation of gas bubbles. It seems likely that this observation explains the apparently incomplete recovery of combined cations in this single determination.

are given in the last column. These have been calculated in order to provide a partial test of the reasonableness of the values obtained by electrodialysis and incidentally to determine approximate empirical factors for interconverting the quantities determined by electrodialysis and by combustion. The combining weights shown are somewhat higher than can be accounted for if the ash is largely composed of the oxides of potassium, calcium, magnesium, iron, or aluminum, the combining weights of which are 47, 28, 20, 26, and 17 respectively. Since spectroscopic examination of the ignited residue indicated the presence of relatively large amounts of calcium, aluminum, and silicon, the average combining weight may be accounted for in part by the presence of silicates or of silicon dioxide, neither of which would affect the equilibria with dilute acids. In addition, part of the sulfur of the protein is oxidized to sulfate on ignition, and the weight of the ignited residue, and thus the empirical combining weight is increased. The combining weights in the table are very close to those which would characterize the sulfates of the cations known to be present.* A comparison of the combining weights in the table with the combining weights calculated from the results of direct titration of the ignited reidue with acid, showed that less than half of the residue obtained after combustion was capable of combining with acid. This is consistent with the fact that a very large part of the ash is in the form of sulfate. The results tabulated also furnish a strong indication that the average combining weights of the ash from lots of wool characterized by widely different ash contents are sufficiently alike for these combining weights to be used as factors for interconverting the results which would be obtained by electrodialysis and by combustion.

An example of the manner in which the electrodialysis may be applied to routine mill analyses is given below. Both ash and cation determinations were made on pieces of undyed worsted and woolen cloths as different stages of the neutralization and rinsing processes directly following the carboniz-

* Gravimetric analysis of some of the ashes reported in Table 3 showed that 42% of their weight was $SO_4^=$.

TABLE 4

Ash content of undyed pieces of wool cloth at various stages in processing. Averages of three determinations on samples of 0.8 g soaked for 2 hours in 3 ml. of 0.15 *H* hydrochloric acid, and electrodialyzed for 2 hours.

Nature of cloth	Stage in process	Cationic ash	Ash by combustion at 700° C	Empirical equivalent weight of ash
		milliequiv./g.	mg/g.	g.
Lightly woven worsted	[a] water rinse	0.025	0.65	26.0
	soda washed	.439	23.6	53.8
	partially neutralized	.071	5.0	70.8
Open weave, woolen and worsted combination	[a] water rinse	0.020	0.90	45.5
	soda washed	.143	8.15	57.0
	"completely neutralized"	.015	1.35	89.5

[a] These samples contained over 2% of sulfuric acid.

ing process.* The results of these measurements are summarized in Table 4.

All the samples, including those which had been carbonized with sulfuric acid and then merely rinsed with water, contained a nonvolatile mineral residue. In those samples which were merely rinsed, this residue was so small as to render the calculated combining weights uncertain. However, the combining weights of the much larger amounts of ash obtained from the two samples treated with sodium carbonate are closely similar and are not far different from the combining weight of sodium carbonate, which is 53. Owing to the large excess of ash in these samples over the amount of ash originally in untreated wool, the effects of the original ash on the average combining weight of these samples is practically negligible. Nevertheless, the close agreement between the exprimental and theoretical combining weights of the ash of these samples may be in part coincidence. A considerable part of the carbonate originally present must, however, have been transformed into sodium sulfate by neutralization of sulfuric acid remaining on the cloth; if all of it were so transformed, the combining weight would have been 71. It therefore appears likely that sulfates and oxides (formed by decomposition of carbonates, and from sodium ions combined with the wool itself) were present in addition to carbonate, with a resulting average equivalent weight close to the theoretical value for sodium carbonate. This suggestion receives some measure of support from the fact that a large part of the soda *in the unburned sample* had reacted with sulfuric acid and was present as sulfate. Thus, only 0.24 millimole of acid per g. was required to neutralize the free base in a sample of the soda-treated cloth, although the total cation equivalence, as determined by electrodialysis was 0.44 millimole, almost twice as great.

As the table shows, the combining weights tend to rise after even par-

* The authors are indebted to Mr. Werner von Bergen, Director of the Research and Control Laboratories, Forstmann Woolen Company, Passaic, N. J., for furnishing the samples used. A description of the stages in the neutralizing and rinsing process to which the table and text refer will be found in the American Wool Handbook, 1st edition, page 563.

tial neutralization and washing out of the soda-ash. On "complete neutralization" they rise still more. Since the "neutralized" material was low in ash before the soda treatment, the ash remaining after neutralization must have resulted largely from this treatment. The rise in the combining weight indicates that most of the carbonate, which would yield an ash of low combining weight, has been removed by washing, leaving sulfates of sodium and, to a much less extent, of other heavier ions initially in the fibre.

The feasibility of determining electrodialytically the sulfuric acid in the carbonized fibres, as distinguished from the sum of this quantity plus the sulfate formed in combustion, has been demonstrated in work with wool yarn previously treated with sulfuric acid. Samples of wool in the central chamber of the apparatus were immersed in 0.15 *M* sodium hydroxide and exposed to the passage of current for four hours. At the end of this period the contents of the anode chamber were analyzed gravimetrically for sulfate. The results agreed closely with similar sulfate analyses made on the total hydrolytic products of other samples of sulfuric acid treated wool which had been decomposed by hot concentrated hydrochloric acid.

By simultaneously measuring the hydrogen ion equivalence of the cations and of sulfate and determining the difference between them, a figure of interest in mill technology, the content of excess acid or base, may be obtained.

3. The electrodialytic determination of acidic and basic groups of fibres and other nondiffusible materials. Application of the methods already described permits the estimation of the acidic or basic groups of substances which possess the following properties:

(1) Nondiffusibility through cellophane or collodion.

(2) The capacity to form tightly bound complexes with at least one species of cation (for the estimation of acidic groups), or with at least one species of anion (for the estimation of basic groups). The complexes must not readily dissociate or hydrolyze on dialysis or washing sufficiently prolonged to remove the unbound excess of these ions. Such complexes are formed by calcium in the case of dewaxed cotton, and by various acid dyes in the case of protein substances.[7]

(3) A large difference between the strength of the acidic or basic group to be estimated and the strengths of the other acidic or basic groups present. Thus, in cellulose, the estimation of the total number of carboxyl groups with calcium is possible only because these groups are very much more acidic than the hydroxyl groups; the latter do not combine with base under the conditions used.

The acidic (or basic) groups of substances which fulfill these three requirements may be determined by engaging the groups with a suitable cation (or anion) by treatment with a suitable base (or acid), removing the excess reagent by washing (if the product is insoluble) or dialyzing (if the product is soluble), and electrodialyzing to determine the amount of cation (or anion) remaining combined.

In order to illustrate the application of the above general procedure, the determination of the acidic groups of cotton is described below.

Table 5 gives data for the cationic ashes of samples of dewaxed cotton which had been soaked in lime-water for 3 hours, and washed with running distilled water for 24 hours. Comparison of these results with those of

TABLE 5

The hydrogen-ion equivalence of the cationic ash of lime-washed, dewaxed cotton.

Weight of fibres, dry basis	Cationic ash	Cationic ash
g.	milliequiv.	milliequiv./g.
0.749	0.0474	0.0633
.776	.0500	.0644
.780	.0506	.0649
		Mean 0.0642

Table 1 shows that the lime-water treatment does not increase the cationic ash of dewaxed cotton appreciably. It has been stated (Section III–1) that the hydrogen-ion equivalence of the cationic ash of dewaxed cotton corresponds closely with the number of carboxylate groups as determined by an independent method—the direct titration of these groups with acid. It therefore follows that the cationic ash of lime-washed dewaxed cotton is a measure of the total number of carboxylate groups of the fibre, and further, that the carboxyl groups of unprocessed cotton are almost entirely present as the carboxylates of various tightly bound ions.[3]

The method has also been applied to the measurement of the acidic groups of depectinized cotton. The material was prepared by the modification of the American Chemical Society procedure for the purification of cotton described by Worner and Mease.[8] This procedure involves the extraction of the fibres with a boiling 1% solution of sodium hydroxide. At a later stage in the process the fibres are thoroughly washed with a 1% solution of acetic acid, a treatment which undoubtedly removes some of the

TABLE 6

The hydrogen-ion equivalence of the cationic ash of lime-washed, depectinized cotton.

No.	Weight of fibres, dry basis	Cationic ash	Cationic ash
		milliequiv.	milliequiv./g.
1	0.5168	0.0054	[a] 0.0104
2	.7063	.0067	.0095
3	.8775	.0079	.0090
4	.754	.0069	.0092
			Mean 0.0095
5	.746	.0080	0.0107
6	.731	.0067	.0090
			Mean 0.0099

[a] Since the titer differences from which the data of these tables were computed had a precision of 1 part in 25, the data could be represented either as shown, or by one less significant figure. They are given as shown to permit a better estimate of their reliability.

cations initially combined with the fibre or taken up from the basic solution. In order to replace cations on the carboxyl groups the samples were soaked in a saturated solution of calcium hydroxide for 3 hours, and washed with running distilled water for 24 hours. The results of determinations of the cationic ashes of these samples are given in Table 6. Samples 1–4 were extracted with alkali for 4 hours, and had a maximum acid-binding capacity of 0.008 milliequivalents per gram. Samples 5 and 6 were extracted with alkali for 8 hours, and had a maximum acid-binding capacity of 0.009 milliequivalent per gram.[3] The data show the close correspondence between the carboxylate content and the hydrogen-ion equivalence of the cationic ash.

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Obituary

William Wallace Buffum, treasurer and director of The Chemical Foundation, Inc., died at the Mountainside Hospital, Montclair, N. J., June 22, after a brief illness of a heart ailment. During the six years that the late Hon. Francis P. Garvan was president of this Institute Mr. Buffum acted as his personal representative on the Board, and was a contributing member as the treasurer of the Chemical Foundation. His advice, based upon his broad experience in the organization and conduct of research, was of great aid to the Institute during its formative period.

Mr. Buffum was born at Friendsville, Pa., Aug. 25, 1888. From 1917 to 1921 he was chief accountant in the Washington office of the Alien Property Custodian. Since 1921 he had been a member of The Chemical Foundation. He took an active interest in the furtherance of chemical education in this country, in the organization of the American Institute of Physics, and in the development of newsprint from Southern pine. He was also greatly interested in the utilization of chemistry in the fight against various diseases, such as cancer, tuberculosis, etc. Through his connection with The Foundation, he became business manager of several periodicals, including The American Journal of Cancer, Sewage Works Journal and The Journal of Clinical Investigation.

He leaves a widow, Mrs. Henrietta Carr Buffum, two sons, William W. Jr. and John Carr Buffum, and a daughter, Miss Marey Buffum, all of 153 Eagle Rock Way, Montclair; also his mother, Mrs. Augusta Buffum of Binghamton, N. Y., and two brothers, Frederick and Harry Buffum.

Abstracts

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I. Fibres (Synthetic and Natural) and Fibre Analysis

Casein-Vinyl Resin Mixtures: Spinning. J. Seltzer. *Rusta*, 1940, V. 15, P. 18–20; abs. in *J. T. I.*, April 1940, P. A175.

A discussion of vinyl resin plastic masses for the production of textile fibres, the preparation and properties of animal and vegetable caseins and the advantages of the use of mixtures of the two for the preparation of fibres, the improvement of casein spinning masses by the addition of glues and gelatins derived from marine algae, and the use of casein-vinyl acetate mixtures for the spinning of fibres of good strength and flexibility. (C)

Cellulose Fibres: Experiments to make Visible the Inner Structure of—by Depositing Extraneous Materials. Ernst Kühnel. *Kunstseide u. Zellwolle*, 1940, V. 22, P. 3–7; abs. in *C. A.*, 1940, V. 34, Col. 2587.

The author believes that the method will lead to a better understanding of the orientation of fibre elements and the presence of short- or long-chain mol. groups. It may also be possible to use this method as an analytical tool in the estn. of the degree of polymerization. (C)

Cellulose Fibres: Strength and Degree of Polymerization. H. Staudinger and J. Jurisch. *Zellwolle, Kunstseide, Seide*, 1939, V. 44, P. 375–7; abs. in *J. T. I.*, April 1940, P. A201. (C)

Cellulose Fibrils: Dimensions and Structure. A. J. Bailey and R. M. Brown. *Ind. Eng. Chem.*, 1940, V. 32, P. 57–63. (C)

CELLULOSE: NATIVE AND REGENERATED. Anon. *Silk J. & Rayon Wld.*, 1940, Mar., P. 22–3; Apr., P. 29–30; May, P. 20–22.

A series of articles giving a brief review of the modern picture of the structure of cellulose, explaining those theories which now appear to be accepted and showing the similarities and differences in behavior of native and artificial fibres. (C)

CHINESE AND OTHER CARPET WOOLS: IMPROVEMNT OF. R. H. Burns, A. Johnston and W. C. Chen. *J. T. I.*, April 1940, P. T37–48.

The complete article, procedure and data referred to in *Text. Rsch.*, April 1940, P. 253 under the title "The Ideal Carpet Wool Tentatively Defined." (C)

COTTON HAIR: DEVELOPMENT. K. Hess. *Klepzig's Textil-Z.*, 1939, V. 42, P. 629–32; abs. in *J. T. I.*, Feb. 1940, P. A112.

Photographs showing the development of cotton bolls and hairs are given and the results of physical and chemical investigations of the hair wall are discussed. The cotton hair in the boll increases in length during the first 20 to 25 days and this period is followed by one in which the hair wall thickens without increasing further in length. Hairs in the first period of development give an X-ray diagram showing two characteristic rings which are attributed to a primary non-cellulosic substance. Ripe hairs give cellulose diagrams. The young hairs contain wax, phosphatide, protein and pectin materials and when these are removed by extraction the young hairs show the same X-ray diagrams and double refraction, swelling and viscosity effects as ripe hairs. Cellulose, therefore, appears to be present in the primary wall but not in the regular lattice arrangement that produces cellulose X-ray diagrams. Possible mechanisms of cellulose formation in the cotton hair are discussed and it is pointed out that the non-cellulosic substance may be an auxiliary substance for cellulose formation or may merely serve to prevent crystallization of cellulose in the primary wall. The cellulose and non-cellulosic substance may exist in the young hair walls in the form of a complex covered with wax. (C)

HEMP FIBRES: CHEMICAL METHOD FOR PREPARATION OF. V. M. Bondarenko. *Len i Konoplya*, 1938, V. 5, No. 10, P. 41–2; *Khim. Referat. Zhur.*, 1939, V. 2, No. 4, P. 126; abs. in *C. A.*, 1940, V. 34, Col. 1854.

Pectin substances were destroyed and the fibre was freed from the accompanying components by treating hemp straw with H_2SO_4 and starch paste. The acid hydrolyzed starch to glucose and formed an acid medium in which pectin produced a gel that was washed away. The acid was neutralized with wood ash. A fibre was obtained which was equal to that obtained by natural retting in color, strength and elasticity. Good results were also obtained by treatment with wood ash or with ash obtained from the combustion of malt grains from alc. distilleries. (C)

PROTEIN ARTIFICIAL FIBRE. I. SPINNING OF CASEIN ALKALI SOLUTION. H. Z. Utaka, K. Nasu and S. Oriu. *J. Soc. Chem. Ind., Japan*, 1939, V. 42, P. 397–8; abs. in *C. A.*, 1940, V. 34, Col. 2180.

The dispersion of casein alkali solns. was markedly improved by addn. of small quantities of Cu, Ni, Co, Fe or Zu hydroxides, resulting ultimately,

after processing, in beautiful wool-like casein fibres. A change in the degree of dispersion of the casein soln. does not appreciably affect the tensile strength or elongation of casein fibre, but a change in spinning velocity or addn. of a large quantity of metallic hydroxide gels does exert a marked effect. Data on the ripening time of casein alkali soln. are given. Mg salts, formalin, acids, etc., were used as coagulating media; for permanent coagulation in a properly coned. soln., 48–72 hrs. or more is required. Casein fibre thus obtained had a max. tensile strength of 1.3 g. per denier and the elongation was 14.0%.

II. Manufacture of Soybean-Protein Fibre. H. Z. Utaka and K. Nasu. *Ibid.*, P. 398. Soybean protein was softened in water and dispersed in a soln. of NaOH, KOH or NH_4OH. A mixt. of equal parts of this alkali soln. and casein soln. was forced through spinnerets (of the rayon type) into a coagulation bath contg. an inorg. or an org. acid and Mg salts. The fibre, which was wool-like and faintly yellow, had an av. tensile strength of 0.71 g. per denier and elongation of 5.2%. (C)

II. Yarns and Fabrics

Cellulose Acetate Staple Fibre: Spinning on Cotton Machines. *Klepzig's Textil-Z.*, 1939, V. 42, P. 455–6; abs. in *J. T. I.*, Oct. 1939, P. A621.

The spinning of cellulose acetate staple fibre alone on cotton spinning machines is discussed. Necessary modifications in speeds and settings and other precautions are outlined and suitable drafts, doublings, etc., for the various stages are indicated. (C)

Cloth Conditioning: New Departure in. Sellers & Co., Ltd. *Silk J. & Rayon Wld.*, Mar. 1940, P. 41.

A 3-in-1 process machine which enables steaming, dewing and conditioning by freezing to be operated in conjunction or separately. The refrigeration apparatus is made in four sizes, and any desired amount of "frost" can be supplied. The apparatus is thermostatically controlled, the actual freezing being created by the high pressure liquid gas principle through a compressor and gilled coils. (C)

Cloth Faults Traceable to Reeds and Healds (Harnesses). M. M. Taylor. *J. T. I.*, Dec. 1939, P. P450–62.

Report of a practical study of warp streakiness in acetate rayon fabrics which demonstrates and illustrates a considerable number of such faults that are traceable to defective reeds and harnesses. All are identical in the fabric with streakiness which is usually credited to uneven yarn or to uneven warp tension, and as frequently found in rayons other than acetates. (C)

Covered-Rubber Yarn: Enemies of. Charles E. Bergamini. *Text. Wld.*, Jan. 1940, P. 67.

What they are and how they may be successfully combatted by correct methods of manufacture and finishing. (C)

DE CODING SLASHER CHARTS. Briggs Young. *Cotton*, Oct. 1939, P. 82–4.

When charts from recorders of automatically controlled slasher cylinders and size kettles show unusual variations, don't blame the instruments but make a careful search for unsuspected trouble. (C)

DRY-CLEANING VS. CLOTH SCOURING. Roland E. Derby. *Text. Wld.*, Oct. 1939, P. 72–3.

Description of a new continuous process for woolens and worsteds that has proved successful at plant of M. T. Stevens & Sons Co., North Andover, Mass. (C)

EMULSION OILING OF MERINO WOOL. P. P. Townend. *J. T. I.*, Mar. 1940, P. T31–36.

The purpose of the experiment was to determine the critical amount of lubricant which might be added to fine woolen blends in order to obtain maximum yarn strength. It had been shown that the strength of a worsted roving first increased and then decreased with continued additions of oleine, and in the case of a woolen yarn oiled with varying amounts of olive cream, the breaking strength increased as the percentage of lubricant decreased from 30% to 22% on the weight of the wool. Since it is generally agreed in the fine woolen trade that emulsion oiling is superior to that with oleine alone, the experiment was confined to the former method. The wool used was 64s Queensland scoured merino. The emulsions used consisted of 50% oleine and 50% water. The maximum amount of lubricant which can safely be added for maximum yarn strength is 20% emulsion. (C)

FELTING IN WOOL FABRICS. W. Klusmeyer. *Klepzig's Textil-Z.*, 1939, V. 42, P. 738–9, 754–5; abs. in *J. T. I.*, Mar. 1940, P. A137.

Examples are given showing the wandering of wool fibres during milling. It is concluded that milling depends on (1) the surface structure of the wool fibre, (2) the vigorous mechanical action during the milling process, (3) the crimp of the individual fibre, and (4) the wandering of free fibres and fibre ends under the influence of the factors mentioned above. (C)

GERMAN RAYONS AND STAPLE FIBRES: CHARACTERISTICS. P. A. Koch. *Klepzig's Textil-Z.*, 1939, V. 42, P. 229–36, 307–10, 361–8, 464–7, 664–8, 735–8; abs. in *J. T. I.*, Mar. 1940, P. A149.

An alphabetical list of German rayons and staple fibres with notes on their nature, characteristics and uses. Slip transparent foil and similar novel strip materials are included. Names of manufacturers, photo-micrographs of fibres, yarns and fabrics, and references to rayon and staple fibre literature are given. (C)

GERMAN STAPLE FIBRES: SINGLE FILAMENT DENIERS AND LENGTHS. P. A. Koch. *Klepzig's Textil-Z.*, 1939, V. 42, P. 769; abs. in *J. T. I.*, Mar. 1940, P. A149.

A table showing the producers, single filament, deniers, lustre characteristics and staple lengths of the various German staple fibre products, including viscose, cuprammonium, acetate, casein and wholly-synthetic fibres. (C)

KAPOK: CARDING AND SPINNING. *L'Ind. Textile,* 1939, V. 56, P. 479; abs. in *J. T. I.,* Jan. 1940, P. A10.

In patented processes for the treatment of kapok, a current of air is used to open and clean the fibrous material and deposit it in the form of a lap on a traveling perforated belt. The fibre is then humidified and carded in a machine of the type used for short wool but with the main carding cylinder running at about half the speed normally used in the treatment of wool or cotton and with other parts of the carding engine running at correspondingly higher speeds. The card slivers then pass to a condenser, and the final spinning operation is carried out on a mule of the type used for short wool. The kapok yarn may be used in weaving and knitting processes. (C)

KNITTING LOOM. N. E. Butt Co. *Text. Wld.,* 1939, V. 89, No. 12, P. 73.

An illustrated description is given of a new knitting loom for the manufacture of curtains, trimmings, wash cloths and table cloths. The warp, carried on spools beneath the machine, is led to the needles through jacks that rotate about the needles to form loops. The weft is fed, as individual yarns or as groups of yarn, to small tubes mounted in holders on the pattern bars, ten in number, that lay the filling in the predetermined order between the warp. (C)

LAMINATED FABRICS: PRODUCTION. L. Light. *Text. Wkly.,* 1940, V. 25, P. 131–2; abs. in *J. T. I.,* Mar. 1940, P. A141.

A review is presented of patented processes for the production of laminated (*e.g.,* collar) fabrics from the first Trubenizing process. The methods are grouped under (1) co-polymerized resins, (2) isobutylene resins, (3) cellulose esters and (4) nitrocellulose. (C)

MACHINE STOPPAGE RECORDING APPARATUS. *Leipz. Monats. Text. Ind.,* 1939, V. 54, P. 243–5; abs. in *J. T. I.,* Feb. 1940, P. A81.

Records of machine stoppages can be obtained automatically by means of a system in which contacts on the machines control, through suitable electrical connections, recording devices at a central recording station. The arrangements are such that records for 30 machines can be obtained side by side on a strip 140 mm. in width. The recording devices may be operated to mark the strip either during the operation of the machine or during the periods when the machine is stopped. By using two contacts on a loom, one on the stop lever and one on the weft stop motion, it is possible to obtain records of weft breaks as well as of the duration of stoppages. Typical records are shown and their interpretation is discussed. The value of the records for control purposes is emphasized and the advantages of this automatic recording system over the usual measurements with stop-watches are pointed out. (C)

MOIST AIR DRYING SIZING MACHINE. Gebruder Sucker G.m.b.H. *Mell. Textilber. Eng. ed.,* 1939, V. 20, P. 149.

An illustration is given of a new heavy duty sizing machine in which the warp does not make contact with the surfaces that heat the air supply;

the heating and drying chambers are completely separated. It is claimed that the size does not cake on the yarn so that splitting of the warp is easy. It is also possible by moving a single handle to cool the interior of the chamber within two seconds. Steam consumption is about 1¾ lb. per lb. of dry warp. On 24s yarn, 4,500 ends, 72 in. warp width, 6% of size, it is possible to run at 43 yards per minute, giving an output of 670 lb. per hour. (C)

PILE EFFECTS MADE ELECTRICALLY. *Am. Wool & Cotton Rptr.*, Mar. 21, 1940.

By a new patented process the pile fibres for producing appliqued effects on patterns of various types, printed with suitable adhesives, are held and applied vertically by electrostatic means, thus producing effects closely simulating woven pile, and certain fine pile effects that are difficult or impossible to weave. The article also compares the results of this process with flock printing and other methods of simulating pile effects. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

DYEING KHAKI SHADES. *Wool Record*, 1939, V. 56, P. 970–3; abs. in *J. T. I.*, Feb. 1940, P. A89.

A review of the different methods of obtaining khaki shades is given. Machinery and dyestuffs are suggested for dyeing loose wool for woolen khaki fabric. Variations in shade in the finished goods are mainly produced by variations in the duration and conditions of milling or by the use of too much soda ash solution and too high a temperature in scouring. Too light a shade may be corrected by mild tinting with cotton dyestuffs of good fastness to light. The same dyestuffs as for woolen khaki may be used for dyeing tops for khaki made from worsted warp and woolen weft, the finishing of which is briefly described. (C)

DYEING: MODERN METHODS OF. Edward W. Pierce. VII. Sulphur Colors. *Cotton*, July 1939, P. 65–6. VIII. Vat dyes. *Ibid.*, Sept. 1939, P. 63–4, 105. (C)

DYEING PILE FABRICS. John C. Kopasz. *Text. Wld.*, Jan. 1940, P. 68–9.

Discusses modern methods for handling various types of upholstery and cloaking fabrics. (C)

DYEING OF STAPLE FIBRES. A. M. Serebryakov. *Sherstyanoe Delo*, 1939, No. 2–3, P. 25–9; abs. in *C. A.*, 1940, V. 34, Col. 630.

Results are given on the dyeing of staple (cuprammonium and viscose) fibres on lab. and large scale with S dyes, indanthrenes and indigosols. S dyes were used satisfactorily on lab. scale. Most indigosols gave good results while indanthrenes differed. In all cases the cuprammonium fibres were more intensely colored than the viscose. Stability against light was good. Dyeing with 0–11% S dyes in an Obermeyer app. had very little effect upon the strength of the fibres, giving a small elongation. (C)

DYEING WOOL FAST TO PERSPIRATION. *Wool Record*, 1939, V. 56, P. 1190–1, 1195; abs. in *J. T. I.*, Feb. 1940, P. A89.

A review is given of German and English work in developing methods for testing fastness to perspiration. The test of the Society of Dyers and Colourists is regarded as too exhaustive for general laboratory purposes, but its general conclusions tend to corroborate previously held opinions. In a suggested modified test claimed to be more severe than exposure to perspiration under actual wearing conditions, the sample is rolled between, or plaited with, white wool and cotton, entered at 40° C. into solutions representing alkaline and acid perspiration, left in the cooling liquors for 1 hour, squeezed and dried. The alkaline perspiration liquor consists of 50 g. common salt and 1 cc. ammonia (20%) per litre, and the acid liquor 50 g. common salt and 50 cc. acetic acid (30%) per litre. To judge the fastness, the average of the acid and alkaline test is taken. Details are given of suitable dyestuffs for obtaining satisfactory fastness to perspiration. (C)

DYEING WOOL-LANITAL MIXTURES. S. Vandenhende. *Ind. Text.*, 1939, V. 56, P. 451; abs. in *J. T. I.*, Jan. 1940, P. A30.

In dyeing acid colors on wool-lanital mixtures, bleeding from the lanital, especially during the rinsing, may be avoided by the following method. The dyebath is set with 5 to 10% anhydrous sodium sulphate or 10 to 20% crystallized sodium sulphate, 2.5% sulphuric acid (66 Bé.) and 5 to 6% chrome alum. When the dyestuff is dissolved, dyeing is started in the cold. At first the lanital absorbs the color, then the wool from about 50° C. to boiling point. After about ¼ hr. at the boil, 1 to 1.5% sulphuric acid (66 Bé.) is added till the pH is 1.7 to 2.1. With certain colors a pH of 3 is satisfactory and the addition of the 1 to 1.5% of sulphuric acid is not necessary. The chrome alum does not affect the brightness of the shade. The statement that chrome alum affects adversely the fastness to light has not been confirmed. (C)

FINISHING TREATMENT APPLIED TO COTTON HOSE. Margaret S. Furry and Lillian E. Weidenhammer. *Am. Dye. Rptr.*, 1940, April 15, P. 203–5; April 29, P. 229–34.

Report of a study to determine to what extent improvements might be made in cotton hose by the application of various chemical finishes. (C)

FIREPROOFED TEXTILES: PRODUCTION. L. Light. *Text. Wkly.*, 1939, V. 24, P. 714; abs. in *J. T. I.*, Feb. 1940, P. A92.

A review is given of recent firepoofing recipes especially recommended for curtains and rayon fabrics. The London County Council recommends either (a) ammonium phosphate 1 lb., ammonium chloride 2 lb., to 1½ gal. water or (b) borax 10 oz., boric acid 8 oz., to 1 gal. In French patent 815,454 (E. Boulogne and Soc. Ind. des Dérivés du Soufre) the cloth is passed through a 25% solution of zinc phosphate [$Zn(H_2PO_4)_2$] and then exposed to ammonia fumes. (C)

(NEW) FORMALDEHYDE AFTER-TREATED DIRECT COLORS. *Rayon Text. Mo.*, Sept. 1939, P. 94–5. (C)

GLYCERINE: NEW USES OF—IN TEXTILES. Georgia Leffingwell and Milton A. Lesser. *Rayon Text. Mo.*, Sept. 1939, P. 87–9. (C)

GLYCERIN SUBSTITUTES: PROPERTIES AND USE IN THE TEXTILE INDUSTRY. *Klepzig's Textil-Z.*, 1939, V. 42, P. 587–9; abs. in *J. T. I.*, Feb. 1940, P. A91.

The use of glycerin in the textile industry and the possibility of replacing it with other substances are discussed. The properties of "Perglycerol," "Perkaglycerol," "Lactolin," "P.G. 12" (1:2 propyleneglycol), ethanolamines and sorbitol are compared with those of glycerin and possible uses are indicated. (C)

INSECTICIDES FOR THE CONTROL OF THE CLOTHES MOTH: EFFICACY OF NAPHTHALENE, PARADICHLOROBENZENE AND HEXACHLOROETHANE AS. W. Frey. *Arb. physiol. angew. Entomol. Berlin-Dahlem*, 1939, V. 6, P. 189–98 (through *C. A.*, 1939, V. 33, Col. 9487); abs. in *J. T. I.*, Feb. 1940, P. A92. (C)

MONOCHLORACETIC ACID: USE IN DYEING. M. Richard. *Bull. Soc. Ind. Mulhouse*, 1939, V. 105, P. 196–8. Pli cacheté 2572 of 14/4/1924. Refereed by P. Kormann. Abs. in *J. T. I.*, Oct. 1939, P. A637.

The use of monochloracetic acid as a solvent for basic dyes which possesses the property of fixing the dyes with tannin by a passage in tartar emetic without steaming has already been made the subject of a patent by Geigy A.-G., the use of about 200 g. acid to 10 g. dye being mentioned. In the present communication the author describes the use of monochloracetic acid for increasing the yield and brilliancy of basic dyes. The goods are steamed before passing to a tartar emetic bath and 100 g. of acid to 10 g. of dye are used. This acid may also be used to complete the neutralization of aniline on padded goods when dyeing aniline black. It is claimed that the acid does not injure the fibre. In the referee's report are given the results of tests on cloth dyed with basic dyes according to the method described. A loss in strength of 20% after short steaming and 25% after long steaming treatment is recorded. (C)

RABBIT FUR: COMPOUNDS AND METHODS PROPOSED FOR TREATING—FOR TEXTILE USES. V. Casaburi. *Boll. staz. sper. ind. pelli mat. concianti Napoli*, 1939, V. 17, P. 56–64, 109–20, 121–38 (through *C. A.*, 1939, V. 33, Col. 9656); abs. in *J. T. I.*, Feb. 1940, P. A92.

The methods proposed or patented for treating rabbit fur are reviewed and classified. They consist of treatment with (1) mixtures of acids and oxidizing agents, (2) inorganic and organic acids, (3) aluminum salts with or without acids, (4) organic compounds, (5) salts of phosphoric acid, (6) magnesium chloride or calcium chloride and organic compounds in alkaline solution, (7) compounds that protect the fur during the oxidation. It is now proposed to treat the flesh side of the skin with a thick paste of sodium sulphide and gum of carob beans. The fur obtained is suitable for felting and also for textile purposes. (C)

SILK: CHROME MORDANTING. K. Hishiyama. *J. Soc. Chem. Ind., Japan*, 1939, V. 42, P. 352–5B; abs. in *J. T. I.*, Mar. 1940, P. A139.

The relation between the mordanting efficiency and light absorption in the visible region of chromium chloride and sulphate under various con-

ditions has been spectro-chemically investigated for the concentration of the solutions which was found suitable for mordanting by the so-called "boiling process." The effect of temperature, basicity, addition of salt and sodium sulphate is graphically illustrated and discussed. If it is assumed that the light absorption shown by the chromium salts is not due to the salts themselves, but to the presence of small particles of basic chromium salts, the influences on the absorption curve of the solution must depend on the colloidal nature of the chromium hydroxide particles. From such an assumption it is deduced that there exists a close relationship between mordanting efficiency and the absorption curve of the mordanting liquor. (C)

SILK: INCREASING THE STABILITY OF—TO LIGHT BY PROTECTIVE TREATMENTS. M. I. Babynichev and K. M. Markuze. *Shelk*, 1938, No. 10, P. 24–7; *Khim. Referat. Zhur.*, 1939, V. 2, No. 3, P. 128; abs. in *C. A.*, 1940, V. 34, Col. 1180.

The effect on light-stability of silk of treatment with tannin, hydroquinone, NH_4CNS, hydroxylamine, HCOONa, Na_2SO_3 and thiourea was investigated. Best results were obtained by treatment with thiourea; this was effective for 20-day insolation in summer under glass. The stability of silk to light is increased by increasing the alky. of the impregnating soln. However, silk dyed with Indanthrene Yellow 5 GK was less fast to light with increasing alky., owing to the catalytic action of the indigo dye with an increase of pH, which facilitates the intermediate formation of the leuco compd. (C)

SODIUM COMPOUNDS USED IN DYEING. Noel D. White. *Rayon Text. Mo.*, Sept. 1939, P. 91–2, 96. (C)

SYNTHETIC RESINS FOR HOSIERY FINISHES: DEVELOPMENT OF. A. Kempton Haynes. *Am. Dye. Rptr.*, April 15, 1940, P. 186–9.

Paper presented at Mar. 9, 1940 meeting, South Central Section, A. A. T. C. C. (C)

ULTRASONIC RADIATION: APPLICATION IN THE TEXTILE INDUSTRY. Fritz. *Kunstseide*, 1939, V. 21, P. 246–8; abs. in *J. T. I.*, Oct. 1939, P. A638.

Methods of producing ultrasonic radiation are outlined, various uses of such radiation are mentioned, and the possibility of using it in the textile industry for the removal of air from rayon spinning solutions, for increasing the speed of dissolution of dyes, for perfecting bleaching processes, and for the dispersion of solids in spinning solutions, *e.g.*, for waterproofing or crease-proofing purposes, is briefly discussed. (C)

VAT DYES ON LINEN AND COTTON MATERIALS: IDENTIFICATION OF—(INCLUDING THE DETERMINATION OF THE DYEING CLASS OF ALL DYES COMMONLY FOUND ON SUCH MATERIALS). H. B. Bradley and D. A. Derrett-Smith. *J. Soc. Dyers Col.*, Mar. 1940, P. 97–121.

The behavior of dyeings of all available British, German and Swiss vat dyes in four chemical tests were examined, with the object of compiling tables of characteristics by means of which any vat dye could be rapidly identified on linen and cotton materials. The four chemical reactions in-

volved are simple and rapidly carried out, and the reagents used are common laboratory chemicals. The tables of characteristics are arranged in such a way that any dye under examination may rapidly be found in the tables when its behavior in the four tests has been observed. (C)

IV. Research Methods and Apparatus

Cellulose Materials: Theory of the Viscometric Method of Determination of the Wear-resistance of. A. A. Morozov. *Colloid J.* (U. S. S. R.), 1939, V. 5, P. 525–40; abs. in *C. A.*, 1940, V. 34, Col. 1180.

A cotton fabric was repeatedly washed with a boiling soln. of 1% Na_2CO_3 and 1.5% soap, washed samples were dissolved in Cu NH_4 sulfate and the viscosity of the solns. was measured; η decreased almost linearly with the no. of washings. Detn. of η in a capillary viscometer at various pressures in a H_2 atm. showed that it was abnormal in 0.5 and 1% solns. Washings of the cotton fabric lowered the abnormal viscosity of its solns. to the same extent as the total viscosity, *e.g.*, by 70% after 20 washings. A temp. increase from 20° to 30° lowered the η when its abnormal part was large; otherwise there was only a small change. (C)

Cotton: Drying in Field of Short-wave Condenser. A. A. Morozov. *J. Applied Chem. Russ.*, 1938, V. 11, P. 1675–86 (through *Brit. Chem. Abs.*, 1939, P. B699); abs. in *J. T. I.*, Oct. 1939, P. A656.

The rate of drying of cotton in the field of a short-wave condenser (wave-lengths 10.7 and 14.85 m.) is greater than in a thermostat at 100–105°. The cotton is whiter and less modified than by ordinary drying but its water content cannot be reduced below 1.5 to 3.5%. (C)

Dyed Materials: Fastness to Light; Measurement. H. Rein. *Bull. Féd. Int. Assoc. Chim. Text. et Coul.*, 1938, V. 3, P. 394–8; abs. in *J. T. I.*, Dec. 1939, P. A786. (C)

Dyed Materials: Fastness to Light; Measurement. H. Sommer. *Bull. Féd. Int. Assoc. Chim. Text. et Coul.*, 1938, V. 3, P. 398–412; abs. in *J. T. I.*, Dec. 1939, P. A787. (C)

Electric Hygrometer: An Improved. Francis W. Dunmore. *N. B. S. J. Rsch.*, Dec. 1939, P. 701–14.

Describes a new type of electric hygrometer which has proven superior to other types for radio-sonde use because of its rapid response and ability to function at low temperatures. It may also be used for making and recording humidity reading when the humidity unit is remote from the point of indication. As it is comparatively small it may be used for measuring humidities in confined spaces. Although the device seems simple, it has required two years to bring it to the present stage of development where it gives results accurate to within 2 or 3%. (C)

Fibre Analysis Stains: Standardization. A. Noll. *Papier Fabrik*, 1939, V. 37, *Tech.*, P. 317–20; abs. in *J. T. I.*, Feb. 1940, P. A98.

A proposal of an official German sub-committee on fibre analysis to establish a set of stains of sufficient purity has been met by Mesrs. Merck

and Co. The list is now given under shade, trade name and chemical constitution and comprises (1) acid and resorcinol, (2) mordant, (3) basic, (4) basic mordant, (5) substantive, (6) vat and (7) oil-, fat- and resin-soluble dyes. Their shades on particular fibres are not recorded. (C)

FIBRES: DETERMINATION OF SPECIFIC SURFACE. E. J. Wiggins, W. B. Campbell and O. Maass. *Canadian J. Rsch.*, 1939, V. B17, P. 318–24.

The method developed by Carman (1938) for determining the surface of particles from the rate of flow of a liquid through a bed of the material is shown to be applicable to fibres. Measurements (with a modified form of the apparatus) are reported on fragments of glass wool, Corning's "fibre glass" and Celanese filaments, the liquids being water and benzene. Substantial agreement is shown between the value of the specific surface as calculated from the permeability determinations and from the geometry of the fragments. The nature of the surface in contact with the liquid does not exert any influence on the permeability for such widely different materials as copper, glass and Celanese and also for both polar and non-polar liquids. The procedure may be applied to materials with indefinitely large L/d ratios and with fibre diameters as small as 0.0006 cm. (C)

STAPLE RAYONS: METHODS OF EXAMINING—AND THEIR RELATIONSHIP TO THE REQUIREMENTS OF THE INDUSTRY. W. Weltzien. *Monatsh. Seide Kunstseide Zellwolle*, 1939, V. 44, P. 324, 326, 328, 330, 350–6; abs. in *C. A.*, 1940, V. 34, Col. 1181. (C)

SULPHUR AND CYSTINE: DETERMINATION IN WOOL. A. Schöberl and P. Rambacher. *Klepzig's Textil-Z.*, 1939, V. 42, P. 369–71; abs. in *J. T. I.*, Oct. 1939, P. A657.

The sulphur and cystine contents of a number of wools have been determined. The sulphur was determined by combustion, the products being collected in hydrogen peroxide and the sulphuric acid formed was estimated conductimetrically. The cystine was determined colorimetrically with phosphotungstic acid after hydrolysis in 6 *N* sulphuric acid. There is no discussion of the results, but it is apparent that the cystine found does not account for all the sulphur in the wool. (C)

TESTING FLAMEPROOF FABRICS. A STUDY OF THE FIELD AND METHODS OF EVALUATING MATERIAL TREATED WITH COMPOUNDS. E. F. Hartman, R. Hicks and F. Hartman. *Fire Eng.*, 1939, V. 92, P. 336–9 (through *C. A.*, 1939, V. 33, Col. 8017); abs. in *J. T. I.*, Dec. 1939, P. A788. (C)

TESTING RAYON STAPLE: TENTATIVE METHODS OF. *Rayon Text. Mo.* 1939, Oct., P. 41–2; Nov., P. 37–9.

This Tentative Standard (D 540–39T) of the American Society for Testing Materials is, under its Regulations, subject to annual revision. (C)